THE ECONOMICS OF INDUSTRIAL MANAGEMENT

BY *Walter Rautenstrauch* and *Raymond Villers*

BUDGETARY CONTROL

BY *Raymond Villers*

THE DYNAMICS OF INDUSTRIAL MANAGEMENT

THE ECONOMICS OF INDUSTRIAL MANAGEMENT

WALTER RAUTENSTRAUCH

and

RAYMOND VILLERS

SECOND EDITION

Revised by

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PREFACE TO SECOND EDITION

ONE OF THE MOST rewarding aspects of the research undertaken in preparing this Second Edition of *The Economics of Industrial Management* has been to find that the data available for the decade following World War II strongly confirm the validity of the linear relationship of the profit and loss chart as a reliable standard of measurement for the purpose of profit control. A quantitative measurement of its validity, in the case of a few well-known industrial enterprises selected at random, will be found in Table XX. A similar measurement for all manufacturing industries is presented in Table XXX.

In this *Second Edition*, statistical data have been brought up to date on the basis of the information obtainable at the time the revised manuscript was completed. A special effort has been made to give the source of such data so as to facilitate the work of the reader who, at some later date, may pursue his own research in the light of the new developments.

The potentialities of the use of electronic computers for purposes of accounting, of production control, and of evaluation of the relative worth of alternatives have been given particular attention. The method of differential profit control is extensively discussed. This method, in part related to the increasing use of electronic computers in industry, has been the subject of specific research work by the author in recent years; it can thus be considered as an endeavor to modernize the break-even analysis method developed originally by Walter Rautenstrauch.

The assistance given in the preparation of this edition by many associates and friends is hereby cordially acknowledged. Special acknowledgment is gratefully extended to Mr. Robert C. Crawford, Manager, Business Research, Monsanto Chemical Company; Professor J. T. Elrod, Chairman, Industrial Engineering Department, University of Houston; Professor David S. Fields, Operations Research Office, Johns Hopkins University; Mr. Joseph Gilbert, Assistant General Manager, Society of Automotive Engineers; Captain M. H. Gluntz, Supervisor of Shipbuilding, United States Navy; Mr. Peter V. Norden, Staff Engineer, Engineering Laboratory, International Business Machines Corporation; and Professor Ralph O. Swalm, Department of Industrial Engineering, Syracuse University, who have all offered valuable suggestions. Mr. J. E. Connor, Head, Business Analysis and Methods Division, Bayway Refinery, Esso Standard Oil Company, made it possible for the writer to become acquainted with some of the problems faced in electronic-computer programming as they relate to the present study. Dr. Melvin E. Salveson, Management Consultation Services, General Electric Company, was kind enough to permit the extensive use of his own research work in the application of modern mathematical methods for decision making.

Many colleagues, who have used the earlier edition of the text in the classroom, have made valued and constructive suggestions for change in the presentation of certain chapters. So also have several of the author's students and former students. A special effort has been made to check computation errors and they have helped greatly in this direction.

Miss Mary E. Poole, business librarian at Columbia University, her associates, Mrs. Walter Batts and Mr. Frank E. Gibson, and Mr. Russel Shank, engineering librarian, contributed important services on references; Mrs. Vera K. Taylor competently prepared the typescript; Mrs. Philippe Villers actively participated in the research work and the presentation of statistical data. Finally, the author wishes to express

his sincere and deep gratitude to Mr. Robert W. Voorhees of the publisher's staff for his constant encouragement during the development of this work.

Comment and criticism from the reader will be sincerely appreciated.

Westminster, Vermont RAYMOND VILLERS

PREFACE TO FIRST EDITION

THIS BOOK EMBODIES the results of many years' experience in industry, in teaching, and in research. It is written to serve the needs of the executive in industry as well as those of the student of industrial engineering and management. Most of the examples used to illustrate the principles formulated have been chosen from the authors' practical experience in the organization of industrial enterprises, in the operation of businesses in which they have served at various times as directors, presidents, general managers, and treasurers and in government service both at home and abroad.

The authors are indebted to their many associates in industry and to the members of the staff of the Department of Industrial Engineering of Columbia University for valuable criticisms and suggestions. Special acknowledgment is gratefully given to Professor Robert Teviot Livingston, Executive Officer of the Department of Industrial Engineering. The services are gratefully acknowledged of Professor J. Brooke Willis, of the School of Business, who read and criticized part of the manuscript; Professor William Jaffe, Mr. Seymour Melman, Mr. Sydney Pollack, Mr. Paul Flatow, Mr. Julian Green, Mr. Lawrence Cohen, Mr. Robert Edward Randell, and Mr. Frederick G. Oess, who checked problem solutions, and Miss Marion Thompson, who typed the manuscript and prepared its many tables.

It is too much to hope that the book is without some errors. The authors will therefore appreciate it if any reader will write them in criticism of any part of the text.

Athens, Vermont WALTER RAUTENSTRAUCH
Westminster, Vermont RAYMOND VILLERS

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PART I

VISUALIZING THE BUSINESS

INTRODUCTION

THE DAILY PAPERS frequently report the failures, dissolutions, and bankruptcies of various individuals, partnerships, and corporations. Notices of reorganizations are also given, in which those who have claims or debts have agreed to adjustments in the hope that these enterprises may be saved. Accounts of the earnings of successful businesses and notices of dividend payments are also given as indications of well-managed, economically sound organizations. At times all business slows down and widespread economic distress results. Balancing these hard times and depressions are periods of general prosperity in which work is plentiful and earnings high. Periods of war or international tension create deep economic disturbances of far-reaching consequences. Many explanations of, and opinions on, these fluctuating states and conditions of industry have been advanced, and the attempted orderly arrangement and statement of these observations and conclusions constitute the subject matter of *The Economics of Industrial Management.*

Obviously, some of the fundamental problems of business deal with the relation between cost and selling price. Every manufacturer and merchant endeavors to produce or obtain the goods he sells at costs sufficiently below the selling price to offer attractive profits. Therefore, estimating the probable cost to manufacture and merchandise a product and predicting or forecasting its probable selling price are very important factors in the success or failure of a business. It is only since World War I that serious attempts have been made to develop and use rational methods for estimating the costs of production and marketing and for determining the probable markets for goods and the prices at which they might be sold. Only in quite recent years have a few thoughtful men questioned some of the assumptions on which cost estimates are usually founded and challenged the beliefs businessmen generally hold about markets and prices. The depression which began in 1929 materially stimulated some serious inquiries into the whole field of economic thought. Either there were some factors which determine the success of business enterprise that were not taken into account, or the available facts were not interpreted correctly.

This study will attempt to state what is generally considered to be good practice in dealing with the economic problems of specific business enterprises, to inquire into the theories on which these practices rest, and to develop methods of analysis with which to deal more intelligently with the economic problems of a given business. To solve such problems is essentially the responsibility of management. Thus it appears that the study of the *economics* of *industrial management* is actually one aspect of the broader subject of industrial management as a whole which includes managerial controls as well as managerial economics, and also a study of such problems as those related to the organizational structure of industry, the management of research, the human relations, the planning of production, to mention only a few of them. Such problems are discussed in two other volumes of this series.* In the present study, we will focus attention upon the specific problems of managerial economics.

As almost every other managerial activity, managerial economics concerns itself with both the internal and external affairs of a business.

It concerns itself with the design and operation of a plant for low-cost production. It also concerns itself with sources of raw materials, domestic and foreign markets, legislation affecting taxation, labor relations, and many other problems of the general economy.

* Rautenstrauch and Villers, *Budgetary Control* (1950), and Villers, *The Dynamics of Industrial Management* (1954).

There are thousands of important relations—with commercial and investment bankers, with bondholders and stockholders, with the suppliers and the customers, with the competitors and the public authorities—which must be dealt with.

Such relationships, of course, are not new. The old shop knew them also but their complexity has grown so extensively that there is a difference in *nature* between the problems faced by the old shop and those faced by the modern plant.

The difference is threefold:

1. Due to the increasing complexity in organization, the old and traditional methods used before are now no longer sufficient for the visualization of the situation as a whole.
2. Due to the increasing size of the investments and to increasing competition, problems such as fixed charges, rate of production, depreciation, labor costs, etc., that were formerly considered as negligible, are today most significant. In recent years the trend toward the increasing use of automatic devices in industrial production (often called *automation*), has made it even more necessary to give full attention to the problem of making full use of the available equipment. These automatic devices always require very large investments. Their advantage is that they operate very economically if they are used at full capacity. Their disadvantage, from an economic point of view, is that they constitute a very heavy burden whenever they are permitted to remain idle.
3. Due to the increasing influence of general economic conditions on the well-being of an enterprise, management is now compelled to watch carefully the trends in operation of the whole national plant. The old shop had one main problem: to do a fine job so as to please its customers in an essentially local market. By so doing, it was practically certain of being successful and of enjoying a continuous stability. What modern plant manager could think in those terms? Management today cannot ignore fair and unfair competition, the pressing need for markets large enough to absorb the heavy burden of overhead expenses, the income brackets, the taxes, the purchasing power, the international commercial, and even political, situation.

Economics is now part of the task of management. Economic techniques have been developed and so perfected, especially during the

last decades, that anyone who is not a specialist will find it difficult to follow them and to understand their concepts and special terminology.

This book is an attempt to present methods of solution of the daily problems of business in the field of economics. A special effort has been made to enable the businessman or the student who has no special background in economics to follow the discussion easily.

Although the principles developed could be applied to various kinds of businesses, this book is especially intended for managers of industry and for students in industrial organization and economics.

With that purpose in mind, the best first approach to the subject seems to be a consideration of the fundamental element of modern industry—the machine.

Every machine has certain functional characteristics, such as adaptability to perform certain operations, range of sizes of work, and the skill required for its operation.

But a machine has also certain economic characteristics. They are the ones studied in managerial economics. What is the cost of the machine—cost to possess, cost to operate, charges for capital recovery? What is the economic efficiency of the machine, as compared to that of other machines available to do the same work?

Functional and economic characteristics are, each, distinct attributes. Many machines have been built, many more will be, that are technically perfect, but economical failures.

But managerial economics not only concerns itself with a machine as a unit—it also relates to a group of machines.

The important fact to keep in mind is that the total value of a group of machines is *not* the arithmetic sum of the capacities of the machines that are part of the group.

This is a very general phenomenon. A group of human beings has a life distinct from its individual components. In the chemical world, $C_6H_{10}O_5$ is cellulose or is starch, depending on how these isomers have organized their component molecules.

A bridge may fail because of a faulty tower, even if the cables supporting it are ten times stronger than they need be.

Bottlenecks in the flow of work will reduce the attainable efficiency of the best machine to the capacity of the worst—just as, during the war, a convoy had to cross the ocean at the maximum speed of the slowest ship.

Therefore, it is the value of the machine within the group that managerial economics must consider.

This, indeed, is one of the difficulties of the problem.

Just as an individual is, at the same time, a member of his business organization, of his family, his state, etc., so is the machine, at the same time, a part of different groups.

There is a first integration at the level of the department, a second one at the level of the plant.

But, maybe the plant itself is one of a few operated by a large corporation and depending on the others for its supply. The group to consider in such a case is the whole corporation.

In any case, any plant depends on others for its supplies, its equipment, its markets. Different levels of integration should, therefore, be considered. The economic value of a machine will be entirely different if it is considered individually, or as part of a department, or as part of a plant, a corporation, a group of industries, or as part of the "national plant" as a whole. Its individual functional value, meanwhile, will not vary.

What is true for the machine is true for any other economic factor —the buildings, the capital, the profits, the manpower, the product, etc.

Each factor should be considered not only as a unit but as part of a whole.

The problem is further complicated by the variations in the degree of integration.

Within a plant, despite the progress of scientific management, the integration varies from excellent to fair to poor. It even changes with time.

Within a given group of industries, all the nuances of the rainbow of integration can be found. Some industries have gone through an extensive process of integration; some have not yet started. To illustrate, it is sufficient to mention, for instance, the steel industry on one side and, on the other, the manufacture of buggy whips.

Within the national plant as a whole, the integration is more or less dependent on the national policy.

But, whatever the degree of integration, the fact remains that the economic characteristics of a business have to be studied from various points of view.

This book on the economics of industrial management, therefore, is divided into three parts:

Part I—Visualizing the business.
Part II—Industrial cost characteristics.
Part III—The business as part of the "national plant."

■ I

PATTERN AND MEASUREMENT OF THE ECONOMIC FLOW

A BUSINESSMAN is an investor. He invests either his own funds or those which others have entrusted to him. Instead of investing in securities and managing a portfolio as the financial man does, he invests in machinery and buildings, and in materials and services of many kinds. He naturally expects to make a return on these investments. The amount of the return he may expect will depend on the relation of the amount invested to its utility in the business; consequently he asks the question: Will it pay to make the contemplated investment in either machinery or buildings or materials or services? Frequently he is confronted with two or more choices, and therefore he asks: Which will yield the most return on the investment? After he has made his decision he is faced with the problem of making the investment pay as anticipated. To do this he must know the facts of the business he is operating and, most important, must know what the facts mean. To interpret the facts of the business he must relate them to a frame of reference.

That is, he must be able to state from the facts, and the relationships among the facts, that either correct or incorrect tendencies exist in the business. We will therefore endeavor to develop methods of analysis upon which good decisions in such matters may be founded.

The directors and officers, the department heads, the minor officials, and the workmen in every business are deciding to do "this" and not "that," and the combined effects of all these decisions determine whether or not the business is operating satisfactorily. If the majority of the important decisions made conform to sound economic principles, the success of the business is assured. The question which this statement raises is: What are sound economic principles in any given case? How may one know the conditions under which a maximum probability of economic success may be attained? Is success in business largely a matter of good fortune or chance, or are there certain principles that must be followed if a business is to be run successfully? It cannot be denied that a certain amount of good fortune has attended many men who are financially successful. On the other hand, it is quite obvious that the probabilities of success through dependence on mere chance are far from promising. It has also been observed that certain men seem to run businesses successfully without the consciousness of having followed definitely formulated economic principles, and their success seems to deny any need for studying the economic principles of business enterprise.

Sufficient evidence has been accumulated to show that all business enterprises have a capacity to conform to some very definite economic behaviors, just as machines have certain well-defined characteristics which may be realized by good operation. The electrical engineer controls the operations of electrical equipment successfully when he understands how it behaves under different uses. The steam turbine operates according to well-known principles of thermodynamics; and when these principles are conformed to, the turbine will function successfully. So also business enterprises have been found to possess certain well-defined economic characteristics or principles of operation, and it is the province of this study to uncover and understand them. Such principles of operation are no substitute for managerial ability, but they do provide the information that the executive needs for effective decision making.

THE ECONOMIC FLOW CHART

When the electrical engineer begins a study of an electrical machine, he first traces the flow of the electric current through the

machine to find out how it works or functions. His next problem is to find out why it functions. This leads him to study the principles of electric operation in each part of the machine and to formulate the results observed. We propose to pursue the study of business enterprise by the same method, and begin with the question: How does a business work or function as an economic enterprise? How does a steel company function, for example, not in making steel but from an economic point of view? How does any business work as a money-making enterprise?

The answers to these questions may be approached by tracing out an economic flow chart somewhat after the manner in which a chemical engineer lays out a process chart to show the steps followed in converting given raw materials into specific chemical products. The economic flow chart, instead of dealing with materials in different physical states, deals with values in different forms, such as cash, machines, materials, buildings and goods. The unit of measure of value in the United States is the dollar. From a scientific standpoint it is not an acceptable unit of measurement, because it is very unstable. A measure which one day may contain one quart and some days later two quarts would be very unreliable, to say the least. So it must be borne in mind that the flow chart of values we are about to present is based on the assumption that the unit of measurement (the dollar) does not change throughout the cycle. In Part III we will come back to this question of the dollar considered as the economic yardstick.*

A diagrammatic sketch of the economic flow chart of business enterprises as applied to manufacture is shown in Figure 1. For purposes of illustration, let us assume that a business enterprise is to be started

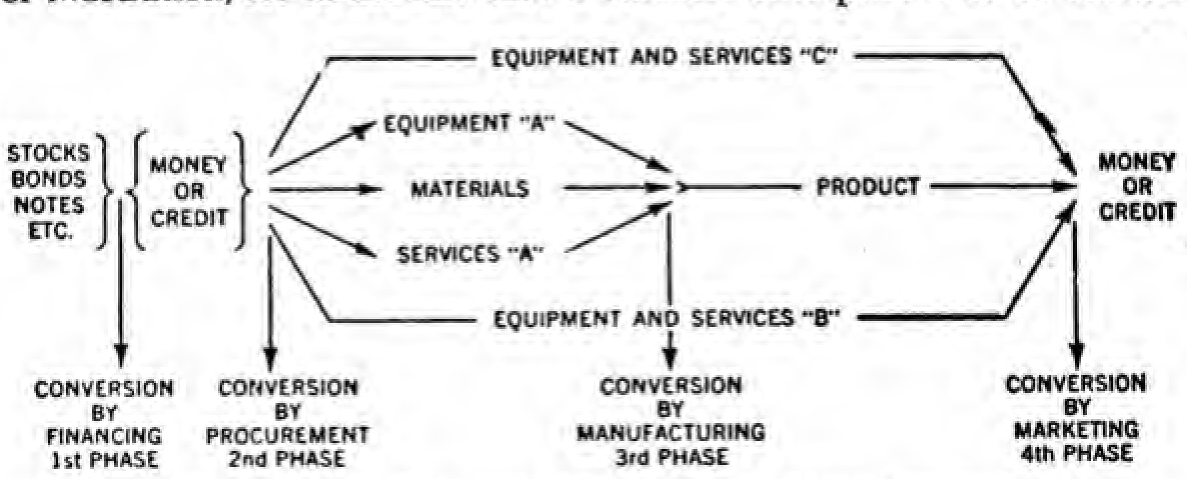


Figure 1. The Economic Flow Chart in Manufacturing

* See Chapter XIV.

with a capital of \$1,000,000, to be acquired through the sale of securities. The beginning of the flow of value changes is first the creation of printed forms of contracts or agreements, termed stock certificates, and next the exchange of these for \$1,000,000 cash or credit. If actual money is paid for the certificates, then the exchange is for cash. If payment is made by check, then the exchange is for credit, because the check when deposited at the bank constitutes a credit to the depositor's account. Thus the first phase consists of a flow of values expressed by the equation:

$$\text{Shares of stock} = \text{Cash or credit received.}$$

If the cash or credit received in exchange for the stock certificates amounts to \$1,000,000, the shares of stock are said to have a total value of \$1,000,000. We shall see later that some of the funds of business are derived from other sources, such as the sale of bonds, bank loans, and merchandise credits. *This phase of the flow may be termed conversion of values by financing.*

The next phase of the economic flow consists in the exchange of some of the cash or credit for buildings, machinery, materials, and services. If, for example, a factory is purchased for \$600,000 and materials for \$200,000, and the services of labor, management, power, etc., for \$100,000, and \$100,000 cash remains, then there has been a flow of values as represented by the equation:

$$\$1{,}000{,}000 = \left[\begin{array}{lr} \text{Factory} & \$\ \ 600{,}000 \\ \text{Materials} & 200{,}000 \\ \text{Services} & 100{,}000 \\ \text{Cash} & 100{,}000 \\ \hline \quad\text{Total} & \$1{,}000{,}000 \end{array}\right.$$

The values given in this equation are determined by the cash value of the payments made; for example, the factory is assigned a value of \$600,000 because that sum was paid for it. We see that what was wholly liquid capital has been partly converted into fixed capital and inventory.

This phase of the flow in values, during which cash is converted into physical and other assets, may be termed the phase of *conversion by procurement.* It is obvious that all the conversions or exchanges of cash for the many items of assets do not take place at the same time, so that the term "phase" is used in a functional sense only. In the operations of a business, all phases of the economic flow chart are going on at the same time; money may be in the process of being

raised while the factory is being enlarged and new machinery may be contracted for while some of the later phases shortly to be described are being carried on. It is important to bear in mind, in forming a mental picture of the flow of values, that the several steps of conversion are arranged in a functional sequence only, without consideration of the time relationships of each unit of flow of values in each phase.

The next phase may be pictured as that in which equipment, materials, and services function together and combine to produce the product. The service of management may be looked upon as a catalyzer which causes the values inherent in machinery, raw materials, labor, and other services to flux into a combination of values embodied in a product or products. Thus this phase, which may be termed the phase of *conversion by manufacture*, may be represented by the equation:

$$\text{Values of} \begin{bmatrix} \text{factory (depreciation)} \\ \text{materials} \\ \text{services} \end{bmatrix} = \text{Value of products}$$

After this phase has been in operation for a period of time, we may find that the following flow of values has taken place:

1. Part of the value of the fixed assets, such as machinery and buildings, has flowed into the product by the process termed depreciation.
2. The raw materials are now embodied in the product, and the value of the materials is now a part of the value of the product.
3. The wages and salaries of employees are now charged to the product, as are the cost of power, insurance, taxes, and other services.

Accordingly, the balance of values accomplished by this phase of the economic flow may be:

$$\begin{bmatrix} \text{Factory} & \$\ 600{,}000 \\ \text{Materials} & 200{,}000 \\ \text{Services} & 100{,}000 \\ \text{Cash} & 100{,}000 \\ \quad\text{Total} & \$1{,}000{,}000 \end{bmatrix} = \begin{bmatrix} \text{Factory} & \$\ 595{,}000 \\ \text{Products} & 305{,}000 \\ \text{Cash} & 100{,}000 \\ \quad\text{Total} & \$1{,}000{,}000 \end{bmatrix}$$

The elements of value contained in the products are:

$$\begin{bmatrix} \text{Factory (depreciation)} & 5{,}000 \\ \text{Material} & 200{,}000 \\ \text{Services} & 100{,}000 \end{bmatrix} = \text{Products, } \$305{,}000$$

The next and last phase of the flow in values is *conversion by marketing*, during which the product is converted into cash or receivables (open account credits, notes, trade acceptances) by the process of marketing. The marketing of the product requires the services of salesmen, of advertising, of transportation, and perhaps warehousing, and therefore the cash exchanged for these services (B) and the depreciation of equipment (B) become part of the cost of the product as delivered to the customer. The equipment and services (C) of the executive offices exercising general supervision of the entire business are also involved in the flow of values. If, then, the value of the product as completed in the factory is $305,000, and $50,000 is spent for services after it leaves the factory and is on its way to the ultimate consumer, the value of the product at the stage where it is placed in the hands of the customer is $355,000. Any sum above this amount received in the sale of the product is profit. If less than this amount is received, there is a loss. Assuming the products to have been sold for $365,000, we find that the conversion of product into money or credit results in the following set of values:

Factory	$ 595,000	=	Factory	$ 595,000
Product	305,000		Money or credit	365,000
Cash	100,000		Cash	50,000
Total	$1,000,000		Total	$1,010,000

Since the goods were sold for $365,000 and the costs of depreciation, labor, material, and service are $355,000, there remains the sum of $10,000, which is the cost to the consumer for the use of capital and is termed the profit.

It will be shown that all business enterprises have the same basic economic problems of converting "values" of one form into "values" of another form. These problems are of different relative importance in one business as compared to another, and these differences are reflected in the organization structure, in the relation of fixed assets to working capital, and in many other ways. It is apparent that the detail problems in the economics of business enterprise have their origins in the four primary phases of value changes or the conversion of values of one form to values of another form.

THE NATURE OF THE PROBLEMS ARISING IN THE ECONOMIC FLOW IN MANUFACTURING

The flow of values in business enterprise may be analyzed in somewhat the same way that the steam engineer studies the flow of energy

and the efficiencies of conversion of heat into work in the thermodynamic cycle or the electrical engineer determines the transfer of the potential energy of the electric current into the dynamic energy of the moving masses of the motor and its attached loads. In the flow of economic values, or of the energy of steam or the electric current, certain principles of operation determine the efficiencies with which each phase of the cycle will take place. In the steam and in the electric cycle, these principles of operation need to be understood thoroughly if the operation of the equipment in which they are used is to be effectively controlled. So also there is need of a thorough understanding of the factors which affect the efficient operation of each phase of the economic flow chart if business is to be managed successfully. To this end it will be necessary first to find the factors which appear at each point where flows of value are taking place and to study the nature of the operation of each factor.

The problems of the first phase of the economic flow chart are

1. The form and nature of the contracts entered into by the corporation with those who furnish the money or credit.
2. The means and the efficiency by which the contracts (written or implied) are exchanged for money or credit.

It is indicated in Figure 1 that the money or credit invested in business enterprise is obtained through the sale of securities to the public. The money thus raised becomes either the permanent capital of the business or its long-term obligations. The company gives in exchange either preferred or common stock for its permanent capital, or bonds for its long-term loans. These investments are based on contracts which give to their holders certain property rights in the assets of the business and certain rights to its earnings. One of the problems in the first phase of the economic flow chart is to obtain the funds for the business with a minimum of hazard to property rights and a minimum fixed claim on its earnings. If, for example, the funds are acquired through the sale of common stock, then there are no fixed claims on earnings and no hazards to property rights. Should the funds be raised through the sale of bonds demanding a fixed annual interest of 7 percent, then the company is obligated to pay 7 percent annually on the face of the bonds, regardless of earnings. Furthermore, if the company fails to maintain certain requirements specified in the bond, such, for example, as current assets equal to the face

value of the outstanding bonds, then the trustees, under the bond, may demand full payment of the bonds, in default of which they may seize and sell the assets of the company in order to satisfy their claims. Again, the securities, either stocks or bonds, when sold through investment bankers under an underwriting agreement, are usually bought by the bankers at a discount. For example, a bond which is bought by the public for $1,000 may be sold by the company to the bankers for $900. The company thus receives only $900 for a bond on which it may have to pay 7 percent on $1,000, and which it will have to redeem at maturity for $1,000. If a group of individuals agrees to provide the company with funds through the purchase of common stock at par direct from the company, then the company receives $100 for each $100 par value stock. This arrangement for securing funds represents a more efficient conversion of "values" through financing than the one involving the sale of bonds through bankers. The conditions under which a company may acquire its permanent capital depend on the state of the market for securities, upon the company's record, if it is an established concern seeking additional funds, and upon many other factors.

During the operation of a business, a company may obtain the use of temporary funds which it uses for a short time. Thus, when it purchases materials on credit, agreeing to pay within 30 or 60 days, it has the use of the funds equal to the value of the materials purchased for a short period of time. As it pays for materials used and buys new materials, it creates in effect a revolving fund. Thus a company's statement of accounts payable represents funds obtained through open-account credits on which it pays no interest. A company may borrow money from commercial banks or from individuals to meet temporary requirements for funds. For these funds it gives its note for 90 days, and may pay interest at the rate of 6 percent per annum.

All the sources from which a company obtains its funds are stated as liabilities in the balance sheet. Thus a company may have funds in its possession (or for which it must give account) as follows:

Accounts payable	$ 100,000
Notes payable	50,000
Bonds	500,000
Preferred stock	1,000,000
Common stock	1,000,000
Surplus	200,000
Total	$2,850,000

Of this total, \$150,000 must be returned in cash within a few weeks; \$500,000 may be payable at the rate of \$50,000 per year for 10 years or \$500,000 at the end of 15 years or on some other long-term basis; \$2,200,000 belongs to the stockholders, of which \$2,000,000 is permanent capital and \$200,000 may be used by the directors either to pay dividends or for other corporate purposes. The above amounts, of course, are not cash items but simply show from what sources the funds were received and because of which the company was able to acquire its assets.

Each of the items of "liability" represents a source of funds used in the business. The amount of the accounts payable is usually the credit supplied by those who furnish materials. Notes to individuals or banks are exchanged for money or credit. These are generally due on definite dates and bear interest. They are commonly known as short-term loans. Long-term loans are secured by bonds and mortgages and may run 5 years, 10 years, or 20 years or more. Those who buy the company's stocks, either preferred or common, supply money or credit on such terms as may be specified in the stock certificate. Such purchasers are known as the owners of the business. The surplus represents the earnings of the common stockholders which have been left in the business. The liability statement of a business shows where the company obtained the money or credit with which it acquired its assets, and indicates the nature of the agreements entered into with those who supplied the money. These agreements establish certain economic conditions of the business and fix the character of some of its financial obligations. For example, if the company raises \$1,000,000 by the sale of 7 percent bonds, it obligates itself to an annual interest charge of \$70,000 until the bonds are retired. If the same amount of money is raised through the sale of common stock, then it has none of the above obligations. It will try to earn 7 percent on the stock, but, if it does not, no risks are involved as there are with a defaulted bond interest payment.

The underwriting and sales agreements which the business enters into in securing its long-term loans (bonds) or invested funds (stocks) determine the efficiency with which it converts its obligations into money or credit. Depending on the state of the market and the availability of capital, the company may have to pay more or less commission to brokers for the underwriting or sales agreements, and these conditions may also determine the interest rate. The whole subject of the capital structure of business enterprise and the numerous

problems of finance on which many volumes are written have their origin in this phase of the economic flow chart. Our consideration of these problems will be confined to the specific effects which typical solutions of these problems have on the economic characteristics of business enterprise.

The problems of the second phase of the economic flow chart are

1. *The economic purchase of land* which means the conversion of money, or credit, into land required for manufacturing purposes, and most suitable with respect to such matters as:

   a. Transportation
   b. Building arrangement
   c. Taxes
   d. Water supply, drainage and sewerage
   e. Available sources of power and labor
   f. Available markets
   g. Available raw materials
   h. Probable future value.

2. *The economic purchase of machinery and manufacturing equipment,* so as to assure a minimum cost of production. By an economic purchase is meant the provision of low-cost manufacturing conditions at a minimum expenditure of funds.

3. *The exchange of money for those materials* which are (a) most suitable at a price for the function to be served, and (b) most suitable at a price for low-cost production of either specific parts or a group or combination of parts.

4. *The procurement of the best services at lowest cost.* Such services are:

   a. Management
   b. Technical
   c. Power, heat, and light
   d. Insurance
   e. Labor.

Thes two phases of the economic flow chart determine the patterns of subsequent economic performances. They establish the organic features of the enterprise and the limits or bounds of economic operations.

The third phase of the economic flow chart

This phase gives rise to the economic problems of production as far as the use of equipment, materials, and services are concerned. Under this head come all the problems of shop or factory management. Among the problems arising in this phase of the flow of values are:

a. The storage and movement of materials
b. The selection of economic lot sizes to manufacture
c. The design and use of jigs and fixtures
d. The adaptation of labor to the various jobs of production, and to services
e. The economic recording and transmission of instructions
f. Accounting and inspection
g. The selection of new and more efficient machinery and processes in keeping with engineering development.

The fourth phase of the economic flow chart

Here is involved the use of equipment such as warehouses or retail stores, and the services of salesmanship, including advertising, to convert the "value" of the product into cash or accounts receivable. The general problems involved are:

a. Creating a desire to possess among those who have the need and the means to buy.
b. Providing the system of distribution which will enable purchasers to obtain the products conveniently.

The object is to obtain maximum sales per dollar of marketing cost and maintaining good will at the same time.

It is difficult to separate these problems, because they are all intimately related to one another. The solution of any particular economic problem of business enterprise is quite similar to the treatment of the human body in health and in disease. Both surgery and therapeutics, though directed toward a specific organ, must proceed with due regard to the general relationship of the affected part to the functioning of the body as a whole. Again, just as the body must be treated in terms of its total environment, so also must a business enterprise be managed with regard to the economy as a whole. Temperature, humidity, solar radiation, water supply, sewerage, and the mineral content of the food supply establish the environmental conditions which determine the health of human beings.

The general well-being of the people in the matter of purchasing power, the tariff in relation to domestic and foreign markets, national

and international political conditions, the discovery of new materials, and the invention of new machines and processes are some of the environmental factors which must be dealt with in solving the economic problems of business enterprise as a whole.

The best solution of the economic problems of business is based on the quantitative measurements of economic forces. But often the data are not available, particularly data on the general economic environment. The methods and means for measurement are frequently based on assumptions and depend on techniques which are not always verifiable or probable in experience. As a result of these situations, the literature on the economics of industry does not always present a complete point of view on the problems with which it deals, and therefore the conclusions derived are often limited in their scope of application, and possible solutions are often empiric.

One of the most important matters to bear in mind in studying the problems of industry is that all formulated relationships which are set up to show how one economic factor is related to another are based on certain assumptions which, if not true, invalidate the whole equation. Also, both the assumptions and the data used determine the probability of calculated results being verified by experience.

THE EFFICIENCY OF THE FLOW OF VALUES

Since the efficiencies of the several phases of the economic flow chart determine the state of the enterprise, one may ask: What are some of the circumstances which affect the efficiencies of the economic flow chart, particularly its last three phases?

It is obvious that a business is started or kept in operation by the force of its purchasing power, through which it acquires buildings, machinery, and materials and hires labor and services of all kinds as needed for its many activities. Not only at the inception of the business but also during its life and growth, money or credit is being transformed daily into the equipment and services required to conduct the business. Much depends on the efficiency of conversion by procurement and, at the same time, there are no satisfactory units and means by which it may be measured.

There are no generally accepted rules by which it may be determined that the funds have been wisely spent, because the effectiveness of the investment depends in some measure on future events. Business enterprise is a venture, the success of which can be judged only by its outcome. One of the objects of this study is to develop methods of estimating the probabilities of success in business enterprise under

given economic conditions. The results attained in business as measured by profits are due to the effectiveness of equipment and management, and to adequate funds or credits, and it is impossible to determine how equipment, management, or credit each contribute separately to the final total results. It is not to be assumed, however, that there are no general principles which may be applied. This phase of the economic flow chart is the one during which some important characteristics of the business are established. For purposes of illustration, let us assume that a businessman desires to manufacture and sell a certain commodity and finds that he can invest $500,000 in the enterprise. He makes plans for a factory which he builds and equips at a cost of $450,000, leaving only $50,000 available for working capital. He then finds that in order to operate the factory at full capacity he should have at least $300,000 with which to buy materials, to pay the labor and other service costs, and to merchandise the product. Accordingly, without sufficient funds or credit to operate the factory to full capacity, the investment in buildings and machinery is largely dormant, and hence the conversion of purchasing power into fixed capital and working capital in these ratios was very inefficient.

Another businessman, deciding to enter the same industry, with an equal amount of purchasing power at his disposal, proceeds to build a plant at a cost of $300,000 and operate with a working capital of $200,000, which is the amount required for operating the plant to full capacity. The second man has converted his funds more efficiently than the first man.

A third businessman entering the same industry with a like amount of capital may, upon careful study, find that because of the small quantity required he can purchase about 50 percent of the detailed parts of the product from other manufacturers more cheaply than he can produce them himself. Accordingly, he decides to build a plant to manufacture fewer parts himself but, by purchasing the other parts, to assemble the same volume each year which the second manufacturer above referred to can produce. His plant investment becomes $200,000 with a working capital of $300,000. This may be a more efficient use of funds than the second case above cited. There are a number of ways in which this flow of values may be begun, each having a different effect on subsequent phases.

The transfer of funds, possessed or acquired through credit, into the fixed assets and working capital of the business establishes the first elements of success or failure of the enterprise. Not only does the ratio between the fixed capital to working capital condition the fu-

ture operations of the business, but the *usefulness* of the equipment, materials and services procured is also a determining factor.

A competent engineer will design and build a plant at relatively low cost and high productivity while an engineer less competent will spend perhaps 50 percent more money in building a plant of low productivity. The efficiency of conversion is high in the first instance and low in the second. Likewise, a competent designing engineer may be engaged for $15,000 a year and succeed in so designing the product, with respect to both function and cost of production that sales are increased and costs lowered. Another engineer, who could be engaged for $8,000 a year, may not be able to design so good a product. The higher salary will represent the more efficient investment, yet the relative worth of the two investments cannot be determined quantitatively.

The purchase of materials ill-adapted for use in the production entailing high cost of fabrication, even though procured at low first cost, represents an inefficient use of funds. Likewise, the purchase of high-priced material for use in making parts for which a much cheaper material would serve the purpose as well represents an inefficient use of funds.

A management which is unprogressive, without initiative and executive force, even though engaged at low cost, represents an inefficient use of funds in providing this class of service. The funds of the business are constantly being used to purchase the tangibles and the intangibles of commerce and the materials and services necessary to the conduct of business. Every day decisions are made to buy some things or to hire somebody in anticipation of their being the best that can be secured for the money paid. In the average business many people are engaged in making these decisions, and, if the business is to be profitable, all these decisions must, by their combined and cumulative effects, contribute in the most effective manner to carrying out the objectives of the enterprise. Accordingly, there must be clearly defined objectives, specifically determined areas of responsibility, methods and means for measuring the effectiveness of attainment, and means of coordination and control. In other words, the efficiencies of the value changes depend entirely on the organization and management which directs the use of funds and credits. As civilization becomes more complex, that is, expresses itself through a greater number of social agencies and cooperative groups in all fields of human interest, and these are dependent upon and related to the economic structure, it follows that more complex types of organizations

and higher, more differentiated degrees of skill are demanded to operate business enterprises. Together with the development of the intellectual capacity necessary to operate the more complex social agencies of modern society, there must also be developed a higher sense of social obligation on the part of individuals charged with responsibilities to the group.

The purchaser of raw materials must have skill to decide which of many materials offered is best for the business, and he must also have sufficient character not to give the order to the vendor who gives him the most expensive present. The manufacturer should not be compelled to engage many unnecessary workmen in building his plant because the local labor leader operates a "racket" in labor. Demoralizing influences such as these break down the morale of organization and management, and set at naught the possible good results of skilled service. No study of economic procedure is complete unless it recognizes the parasitic influences which militate against the efficient conduct of business. *It is at this phase of the economic flow,* during which funds are exchanged for commodities and services, that the demoralizing influence of unprincipled practices is largely felt.

The efficiency of procurement requires not only that each expenditure shall result in the maximum value for the minimum outlay of funds, but also that a proper balance shall be maintained for each expenditure in relation to the funds available. The problem of relative values is ever present. It may be more economical to purchase certain materials in carload lots, for example, but, if such procedure would exhaust credit and prevent the installation of fire sprinklers with resulting reduction in insurance payments, the economy of the whole may be affected adversely.

The efficiency of operation of the third phase of the economic flow chart is conditioned in some measure by the efficiency of the preceding phase, and particularly by the ability of the management to make effective use of the machinery, materials, and services at its disposal.

The objective in operating a factory is to obtain the lowest attainable unit cost of manufacture. Most of the work in scientific management during the past twenty years has been directed toward this end. Among the classes of problems arising at this point are:

1. The effective use of materials
2. The maximum output per wage dollar
3. The maximum output per service dollar
4. The most rapid turnover of working capital.

The fourth phase of the economic flow chart requires that management reconcile the need for satisfying consumer demand with the need for using economic methods in the utilization of materials and in processing. The variety of styles and sizes of products manufactured in a single plant by the modern industrial enterprise has introduced an increasingly serious element of complexity. Another problem results from the fact that goods are not, as a rule, sold for cash by the manufacturer. The profit in this case is only a potential profit. If some customers do not pay their accounts for one reason or another, potential profits may not be realized. Accordingly the value, of that for which the goods have been exchanged, is always open to question if it is in the form of some sort of credit instrument. The efficiency of the fourth phase of the economic flow chart depends therefore on the competence of the management, the effectiveness of the marketing methods employed, and the credit policies of the company.

The subject matter of the economics of business enterprise is derived from what occurs in the four phases of the economic flow. Since this book is written primarily for students of engineering, the main emphasis of its treatment will be on those activities with which the engineer is more closely identified, namely, procurement, research, and manufacturing. The problems of financing and marketing will receive only as much consideration as may be necessary to illustrate their general relation to the problems of procurement, research and manufacturing.

RELATING SPECIFIC OPERATIONS TO TOTAL OPERATIONS

As we view the entire flow of value changes, we are impressed by the fact that many individuals are controlling and directing these changes. The purchasing agent exchanges the company's funds or draws on its credits for thousands of articles each year. The shop superintendent directs the service of labor to innumerable tasks each day and thereby controls the exchange of the wage dollar for inventory. The general manager directs the exchange of the company's funds for new productive machinery, the maintenance and operation of which, together with its depreciation, appear in the cost of the inventory.

This emphasizes the fact that all factors which influence the efficiency of the flow of values are closely interrelated. While it is important to consider each simple aspect of the economic flow (*efficiency of specific operations*), it is equally important to consider the enter-

prise as an integrated whole (*efficiency of total operations*). In this study, a special effort will be made to give full attention to both the efficiency of total operations, more specifically discussed in Part I, and the efficiency of specific operations, more specifically discussed in Part II.

Business enterprises differ one from another in the relative influence of different factors in the economic flow chart. In some industries the processes of manufacturing, particularly the machinery of manufacturing, are controlling factors, while the service of labor is relatively less important. This is the situation in the production of cement, granulated sugar, flour, and of paper, to mention a few. In the manufacture of ships or of steel dies for forging and drawing operations, the labor factor assumes a greater importance. In the manufacture of scientific instruments the procurement of materials is less important than in the meat-packing industry, but the labor factor is just the reverse. Conversion by marketing is a relatively small factor in the newspaper business as compared to the automobile business.

Technological progress may also bring deep changes in the structure of any given industry. In recent years the increasing use of automatic equipment has tended to reduce the importance of unskilled or semiskilled labor as compared to the machinery of manufacture and the service of trained technicians. This trend is likely to become more accentuated as more progress is made in the direction of automation. It may have wide repercussions on our social and economic structure.

Qualitatively, all industries follow the general economic pattern of the economic flow chart. *Quantitatively*, however, the incidence of certain factors in the flow of values is such that the widest differences in policies of operation are required. It is important to visualize the general relationships in the economic flow chart in order to acquire a proper perspective of the whole before the policies through which these relationships are brought under control are established. With such visualization a business may be operated through the application of *principles*. Without such visualization a business is necessarily run by *rules*. Rules are means for maintaining a state of things. Principles are dynamic means for adapting procedures to changing conditions. Since business is always in a state of flux, it is imperative to success that there shall be guiding principles of procedure, and these principles can be discerned only when there is a full and complete understanding of the whole sequence of value changes and of the relationships of the factors which are influencing these changes.

A prerequisite to this full and complete understanding is a reliable

recording of the flow of values showing the amount of money involved, the nature of the transaction and the time at which it did occur.

To provide such a recording is the primary goal of the accounting process.

FUNDAMENTALS OF THE ACCOUNTING PROCESS

It is not intended here to go into the details of accounting techniques. We shall simply consider the fundamentals of the accounting process, an understanding of which is necessary to perform managerial functions. We shall also give some attention to the efforts made in recent years to adjust the accounting process to the new developments in the use of accounting machines and electronic computers.

More often than not, even a brief discussion of the fundamentals of accounting is somewhat annoying to one not familiar with accounting techniques and not intending to study them in details. This is mainly due to the fact that accounting techniques use a terminology and follow an approach which, at first, may well seem to be unnecessarily complex.

A thorough understanding of the magnitude of the problem faced by the accounting function will enable anyone to recognize that the complexity of accounting techniques is unavoidable and should be accepted as such. Furthermore, by relating these accounting techniques to the economic flow chart previously discussed in this chapter, it should be possible to make them meaningful without studying them in details.

The magnitude of the problem faced by the accounting function can be measured in quantitative terms by evaluating what can be called the "speed" of the economic flow.

According to the data presented in its report to the stockholders, General Motors Corporation's net sales and total operating expenses were as follows during the year 1955:

Net Sales	\$12,443,277,420
Total Expenses	\$11,343,012,165

By subtracting expenses from sales, one determines the operating profit made during the year. Let us do the opposite. Let us *add* expenses to sales. This gives a total of:

$$\begin{aligned} \text{Sales} + \text{expenses} &= \$12{,}443{,}277{,}420 + \$11{,}343{,}012{,}165 \\ &= \$23{,}786{,}289{,}585 \end{aligned}$$

This total of approximately 24 billion dollars is a measurement of what can be called the "speed" of the economic flow at General

Motors. It measures the total amount of money that, during one year, went into and out of the corporation operation, in the form of sales and current expenses, without regard to capital investment.

It is the duty of the accounting function to record all the transactions, the total of which amounted to this figure of 24 billion during the year.

Assuming that the accounting departments of the corporation operate on the basis of about 40 hours a week with some periods of overtime work at the end of each month, we can consider that the recording of these transactions amounting to a total of 24 billions of dollars during the year have been performed by accounting departments which have worked approximately 2,400 hours during the year. Dividing the total amount of money involved in the economic flow by the number of work hours available for recording the transactions of the economic flow gives us what is the speed of the economic flow during the period considered, i.e.:

$$\frac{24{,}000{,}000{,}000}{2{,}400} = 10{,}000{,}000$$

This means that the accounting departments must record transactions which on the average flow at the speed of about 10 million dollars per hour of recording work. Each of these 10 million dollars, whether a dollar of sales or a dollar of expense, has to be accounted for. This gives an idea of the magnitude of the task created by the speed of the economic flow at General Motors.

Granted, this is the largest manufacturing corporation in existence. But the reader, by making a similar computation for any company of his own choosing, can easily check the fact that the economic flow is proceeding at great speed even in a middle-size enterprise.

The situation is further complicated by the following facts:

1. For the purpose of *auditing*, i.e., for the purpose of preventing or at least rapidly detecting any misappropriation of funds, each transaction, whether big or small, must be recorded. The purchase of a few 3 cent stamps must be recorded as well as the purchase of $500,000 of raw material. This means that the accounting process must follow an *analytic approach.*

2. For the purpose of *managerial control*, i.e., for the purpose of optimizing profit, management must get a comprehensive picture of the whole situation, without being flooded by an excessive amount of details. This means that the accounting process must also follow a *synthetic approach.*

To solve the dilemma created by this antagonism between the requirements of auditing and the requirements of managerial control, the accounting process makes a simultaneous use of both the analytic and the synthetic approach. It analyzes each transaction as such and it then synthetizes all transactions by classifying them into subgroups and then into groups. In this respect the accounting process follows a method similar to the one used by the statistician, who also bases his understanding of a situation upon an adequate grouping of data. In accounting, the analysis of each transaction and the subsequent classification of all transactions into groups are dominated by the fundamental double entry principle.

THE DOUBLE ENTRY PRINCIPLE

To understand the full meaning of this principle, let us now return to Figure 1, page 10, "The Economic Flow Chart in Manufacturing." This chart shows that each single happening has always a double aspect in terms of its dollar value of the happening. Because the economic flow is a succession of conversions, every transaction always increases (or decreases) one set of values while it simultaneously increases (or decreases) another by the same amount. The double entry principle is simply a recognition of this fact. By virtue of this principle, each set of values is individualized as an *account* and any transaction is recorded as the decrease or the increase of one account and the increase or the decrease of another account. (Sometimes, more than two accounts can be involved for the purpose of effecting a more thorough analysis of the transaction, but the principles involved are the same.) For instance, if a purchase of $10,000 of raw material is being made and paid in cash, the recording proceeds as follows:

> *Entry 1A.* The set of values called "raw material inventory account" is increased by $10,000.
> *Entry 1B.* Simultaneously the cash account is decreased by the same amount.

Should the payment be delayed instead of being made in cash, the recording would be as follows:

> *Entry 2A.* The raw material inventory is increased by $10,000, because it is not affected by the delay in payment.
> *Entry 2B.* The cash account is not involved in this case. Instead, another set of values, called "accounts payable," will record the

liability for future payment undertaken by the company. It increases by $10,000.

Later on, when payment is made, it is recorded as follows:

Entry 3A. Accounts payable decreases by $10,000.
Entry 3B. Cash decreases by the same amount.

This example illustrates the complexity of the problem of recording. Sometimes an increase in one account corresponds to a decrease in another account (Transaction 1A/1B above); sometimes an increase corresponds to another increase (Transaction 2A/2B); sometimes a decrease corresponds to a decrease (Transaction 3A/3B).

This means that it is impossible to summarize the situation by adding all increases and adding all decreases. This would be meaningless.

The double entry principle is precisely intended to obviate this difficulty. It is based upon the debit and credit rule that makes it possible to summarize the whole situation of the economic flow by adding all debits on the one hand and all credits on the other hand, then subtract one from the other and obtain a meaningful figure of increase or decrease of the total values.

By application of the debit and credit rule, each set of values, i.e., each *account*, is split in two parts: debit and credit. By tradition, the recording is generally effected in two columns, the left one being the debit column (Dr.) and the right one the credit column (Cr.).

The debit and credit rule is so formulated that any transaction, whether it involves two increases (Transaction 2A/2B) or two decreases (Transaction 3A/3B) or one increase and one decrease (Transaction 1A/1B), will always involve a debit in one account and a credit of equal amount in another account.

Thus, the debit and credit concept permits the relating of any two entries involved in one or several transactions regardless of the kind of accounts they are recorded in. It makes it possible to summarize the transactions that have occurred during a given period by totalizing all the credits and totalizing all the debits. This obviously requires that an increase be sometimes called a debit and sometimes called a credit. The same is true for a decrease.

It is always easy, when analyzing a transaction, to recognize when an account is increased (or decreased) by the transaction. But how can we know what to call the increase (or the decrease)? Is it a debit? Or is it a credit? It is necessary to learn how to answer this question if one wants to understand the fundamentals of the accounting process.

The answer is based upon a classification of all accounts into two categories:

First category: Includes all accounts for which an increase is called a debit and a decrease is called a credit. Such accounts are those related either to an *asset* (what we own) or to an *expense.*

Second category: Includes all accounts which follow the opposite rule, i.e., those for which an increase is called a credit and a decrease is called a debit. Such accounts are those related either to a *liability* (what we owe) or to an *income.*

		DEBIT	CREDIT
1	ASSETS OR EXPENSES	Increase	Decrease
2	LIABILITIES OR INCOME	Decrease	Increase

Figure 2. The Debit and Credit Rule

Figure 2 summarizes the debit and credit rule.

At first, the terminology, debit and credit, is confusing to anyone who is not specifically trained in accounting. In fact it should be recognized that it is meaningless. But it is not more meaningless than the use of the + and − signs in electrical engineering. It should be accepted for the same reason as the + and − signs, namely because it is universally accepted by the technicians in the field. It is meaningless in pure logic, but becomes meaningful as the basis for an accepted convention. In fact, the debit and credit concept dates back to the fourteenth century * and is still used as the basis for electronic computer accounting.†

Actually the meaning of the debit and credit rule summarized in Figure 2 is that an increase in assets or expenses (a debit) is to be balanced either by an increase in liabilities or income (a credit) or by a decrease in assets or expenses (also a credit), and that a decrease in liabilities or income (a debit) is to be balanced either by a decrease in

* See Peragallo, Edward, *Origin and Evolution of Double Entry Bookkeeping*, New York, 1938.

† Hereunder pages 36*ff*.

assets or expenses (a credit) or an increase in liabilities or income (also a credit).

The opposition between assets and liabilities on the one hand and between income and expense on the other hand is so obviously justified that it does not require any special comment. The grouping of assets with expenses and of liabilities with income may however seem, at first, to be misleading and even illogical. Yet, the logic of this grouping is the consequence of the very nature of the economic flow shown in Figure 1.

We have seen that every transaction can be analyzed in a conversion involving two sets of values for an equal amount and that at the end of a given period the difference between what has been spent (expenses) and what has been received (income) constitutes the profit (or the loss) for the period.

This means that at the end of a period we can only own (*assets*) what we have acquired by contracting an obligation (*liabilities*) either before the period started or during the period under consideration, less what we have disposed of while reducing our liabilities, plus the difference between what we have earned (*income*) and what we have spent (*expenses*) during the period.

Thus, the fundamental equation of the economic flow is:

$$\text{Assets} = \text{Liabilities} + (\text{Income} - \text{Expenses})$$

This equation can also be written

$$\text{Assets} + \text{Expenses} = \text{Liabilities} + \text{Income}$$

which shows the logic of the grouping used as the basis of the debit and credit rule summarized in Figure 2.

This discussion while enabling the reader to understand the basis for accounting entries may not help the uninitiated post actual entries. In teaching, the author has successfully used the following memory device.

If a transaction involves a cash receipt or disbursement, it raises no problem as to which account should be credited or debited, because it is easy to remember once and for all that a cash receipt means debiting the cash account and therefore crediting the other account involved (in the case of a cash disbursement, the opposite holds true).

The memory device consists in selecting among the accounts involved in a given transaction the one that could have been balanced by a cash transaction without changing the fundamentals of the situation from an accounting point of view. If it is recognized that the cash

transaction would have been a disbursement, cash would have been credited, and therefore the account under consideration would have been debited. This provides the answer. The opposite holds true for a cash receipt.

To illustrate: A given product is sold to a customer who will pay later. Two accounts are involved—sales and receivables. Which should be debited? Which should be credited?

Using the memory device: if it had been a cash sales, a cash receipt would have found place, cash account would have been debited, therefore sales should be credited, so as to balance. As a consequence receivables should be debited.

USE OF ACCOUNTING BOOKS

The methods followed in recording accounting transactions have never been rigidly standardized. In recent years the use of accounting machines and punched cards and more recently the use of electronic computers have introduced new factors of diversification.

At first, the diversity of the methods followed may lead to belief that each method is unrelated to the other ones. This creates some confusion and it is an unwarranted conclusion. Actually there are fundamental principles underlying all modern methods of accounting data processing and this includes the most intricate methods of programming developed in recent years for the use of electronic computers in the field. The writer has been impressed by the fact that all modern methods of accounting data processing, including those related to the use of electronic equipment, can best be understood by relating them to the fundamental principles of accounting, inherited from the past. These principles, in turn, can best be understood by studying them first as they were originally applied, before any effort had been made to increase the efficiency of data processing by making them more flexible and by adapting them to the needs of modern business. For this reason, we will start by studying these principles, as they were originally applied, in the most traditional approach even though this approach is rarely, if ever, used as such in modern business.

The most traditional approach in accounting data processing is characterized by the use of no other records than two single books, the *journal* and the *ledger* and by the fact that these two basic books were originally designed in a rather crude form, to be now described. We will also describe the trial balance, a worksheet used for controlling and adjusting the ledger accounts.

The journal and the ledger in their original form

It is when they are considered in this simple form that these two books can best be used to illustrate the fundamental principles of the accounting process. In this form, the journal is a chronological listing in a single sequence of each and every transaction, showing which accounts should be debited and which should be credited as a result of the transaction. All transactions are listed in their chronological sequence, whether they are large or small, whether they are occurring rather exceptionally or whether they are routine transactions occurring at a high rate of frequency. Figure 3 illustrates this process of recording.

Subsequently, all the transactions thus listed are re-grouped by account. This is done by going over the journal entries and posting them in the other book, the ledger.

JOURNAL

				Dr.		Cr.	
19__ March	26	Machinery	11	15,000	00		
		Automatic Equipment Co	23			15,000	00
		Purchase of automatic screw					
		as per purchase order No 12345					
	26	Smith Hardware Store	34	523	39		
		Sales	2			523	39
		Our invoice No. 6789					
	27	Office expenses	7	118	45		
		Bell Telephone Co.	41			118	45
		Their invoice for March					
	27	Bell Telephone Co	41	119	20		
		Cash	1			119	20
		Their invoice for February					
	28	Raw material	6	50,900	60		
		Albert Steel Co.	22			50,900	60
		Their invoice No. 6078					
	29	Cash	1	68	80		
		Thomas and Co.	35			68	80
		Our invoice No. 6774					

Figure 3. The Page of a Journal in Its Crude Form

In its crude form, the ledger is a book providing a page for each single account.

The posting in the ledger of the first entry shown in the journal in Figure 3 would be done as shown in Figure 4. For the purpose of establishing a convenient reference system between the two books, the page of the ledger is posted in the journal (11 and 23 in Fig. 3) and the page of the journal is posted in the ledger (19 in Fig. 4).

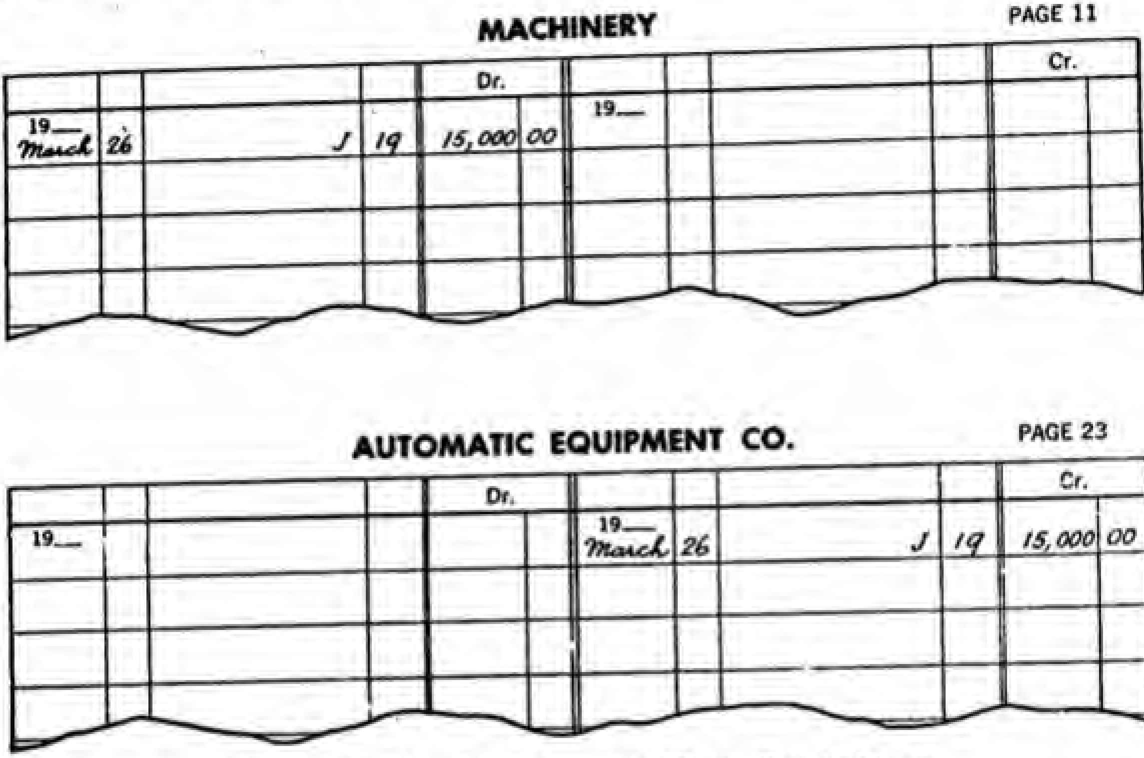


Figure 4. Ledger Accounts in Their Crude Form

Periodically (usually at the end of the month) each ledger account is closed. This is done by taking the balance between the totals of each of the two columns. The balance is posted in the column that shows the highest total (debit or credit). Some accounts are adjusted (for depreciation or allocation of overhead or prepaid expenses, etc.). Some bookkeeping accounts are open at the end of the month (to show profit or loss, etc.).

To facilitate the computations required for adjusting the accounts, all ledger accounts are listed in a worksheet showing, for each account, its debit or credit balance. By adding all the debit balances and all the credit balances, before and after adjustments have been made, it is possible to check so that no computation mistakes have been made. The debit and credit totals should be equal, by application of the double entry principle. The worksheet is called a *trial balance.*

The journal and the ledger in improved forms

In the form described above the journal and the ledger do not differentiate between exceptional and routine transactions. This is their main weakness. While the procedures involved are quite acceptable for a few entries, they are unrealistic when it comes to the recording of thousands of transactions per working hour.

In their improved forms the journal and the ledger provide for such a necessary differentiation. This is done by using several sets of columns in the journal or by using special journals and subsidiary ledgers when warranted.

For instance, if a manufacturer buys raw material only a few times a year, he will follow the above method for recording these few purchases of raw material. At the same time, if he sells goods to a great number of customers at the rate of many sales per day, he will open a *special journal* for sales.

Sales, then, are recorded independently. The recording may be simplified by listing only the name of the customer and the reference number of the invoice and by entering the amount of sales only once in the single column of the special journal. At the end of the period (day, week, or month), the total of this column is entered in the ledger in the sales accounts. This means one entry instead of thousands of single entries in the ledger sales accounts.

The same manufacturer may have so many customers that it would be highly impractical to have one page of his ledger assigned to each customer. He will then group all accounts into one single *accounts receivable* in the ledger and keep each customer's account in a *subsidiary ledger.*

Special journals and subsidiary ledgers are used in many ways. Thus, a special journal may be kept for cash receipts, another for cash disbursements or for payrolls, etc.; subsidiary ledgers may be opened for accounts payable or payroll or for machinery.

Relating the use of special journals and subsidiary ledgers to the fundamental principles of accounting data processing, namely, the principle of chronological recording in the journal and of grouping by sets of values in the ledger, the following can be said:

The use of a subsidiary ledger is merely a convenient method of re-grouping numerous accounts into one account, which is the only one to be listed in the ledger.

A special journal is actually a method of preparing the transition be-

tween the journal and the ledger. In a special journal, one of the two columns of the journal disappears. For the one account that would otherwise be posted in this column there is no specific chronological listing any more. For instance, in a cash receipt journal, there are no debit columns. All accounts listed chronologically are the ones that are credited as a result of the transition: the customer who paid his bill, the bank who lent the money. The total of all these credits at the end of the period provides the amount to be debited to the cash account of the ledger. This is actually done by posting one double entry in the general journal prior to posting the ledger accounts.

USE OF ACCOUNTING FILES

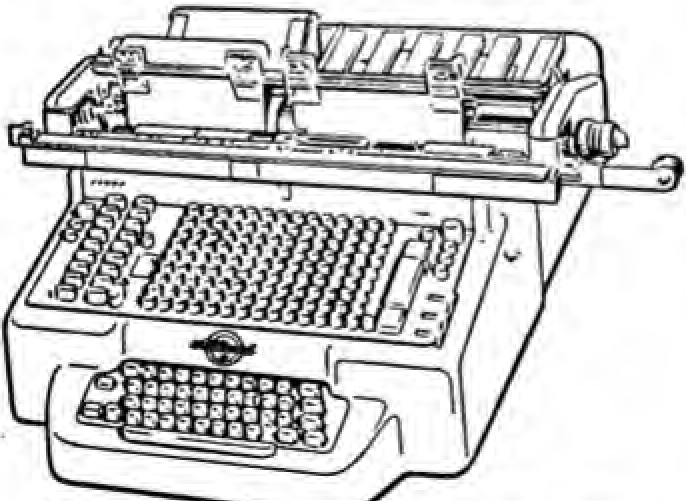
The next step in improving the accounting process is to substitute card files for books for the most repetitive transitions. Such a substitution makes it possible to use accounting machines and punched cards.

Accounting machines

A great variety of machines are available to perform some of the work required in keeping a record of accounting transitions.

Although these machines are greatly diversified, they can, in general, be considered as the combination of typewriter and of computing machine. They are used to post the transactions either on tapes that are transcribed by hand in the books of accounts or directly on cards that do not require any transcription, but are kept on file as a substitute for the books.

As a rule, the cards kept on file do not replace the journal and the



(Courtesy of National Cash Register Company)

Figure 5. An Accounting Machine

ledger themselves. Rather they are a substitute for the special journals and for the subsidiary ledgers previously described. In some cases, however, cards are used as a substitute for the journal or the ledger. They are in such a case kept in filing cabinets and eventually bound by account. Figure 5 illustrates the use of accounting machines and accounting cards in lieu of books.*

Punched card systems

A further improvement consists in using punched cards instead of typewritten cards. As a rule, the punched card is both punched and typed, as shown in Figure 6. Thus it serves a double purpose. Because it is typed, it can be filed and kept as a visual record of the transaction, to be used for eventual auditing. Because it is punched, it can be processed on a punched card machine and thus used for automatic tabulation, adjustments, summarization posting, and reporting. In addition the punched card can also be used for the automatic preparation of special analyses and reports beyond the needs of the accounting process itself (sales analysis, cost analysis, etc.).

To punch the card requires, as a rule, the use of a punching machine operated by a trained operator using a preliminary memorandum prepared by a clerk. The card may also be punched automatically by using mechanical devices, such as a paper tape which is processed by special electric typewriters at the time the documents of original entry (orders, invoices, etc.) are being typed. Summary punched cards are subsequently prepared mechanically by processing the original punched cards.

Master cards can be kept on file and processed together with cards issued periodically to combine with them. For instance, the punched card reporting the number of hours of work performed during the week by a given worker is processed together with the master cards showing his wage rate and tax deductions. The result of this processing is the automatic preparation of the payroll register and eventually an automatically produced payroll check for each worker.†

USE OF MAGNETIC TAPES FOR RECORDING

The first electronic digital computer was completed in 1946. Its purpose was to solve computation problems. It was only around 1953 that

* For more details, see, among others, National Cash Register Co., *A Study of Machine Accounting Methods,* Dayton, 1955.

† For more details, see, among others, Heckert, J. B., and Kerrigan, H. D., *Accounting Systems* (Part V. Punched Card Accounting), Ronald Press, 1953.

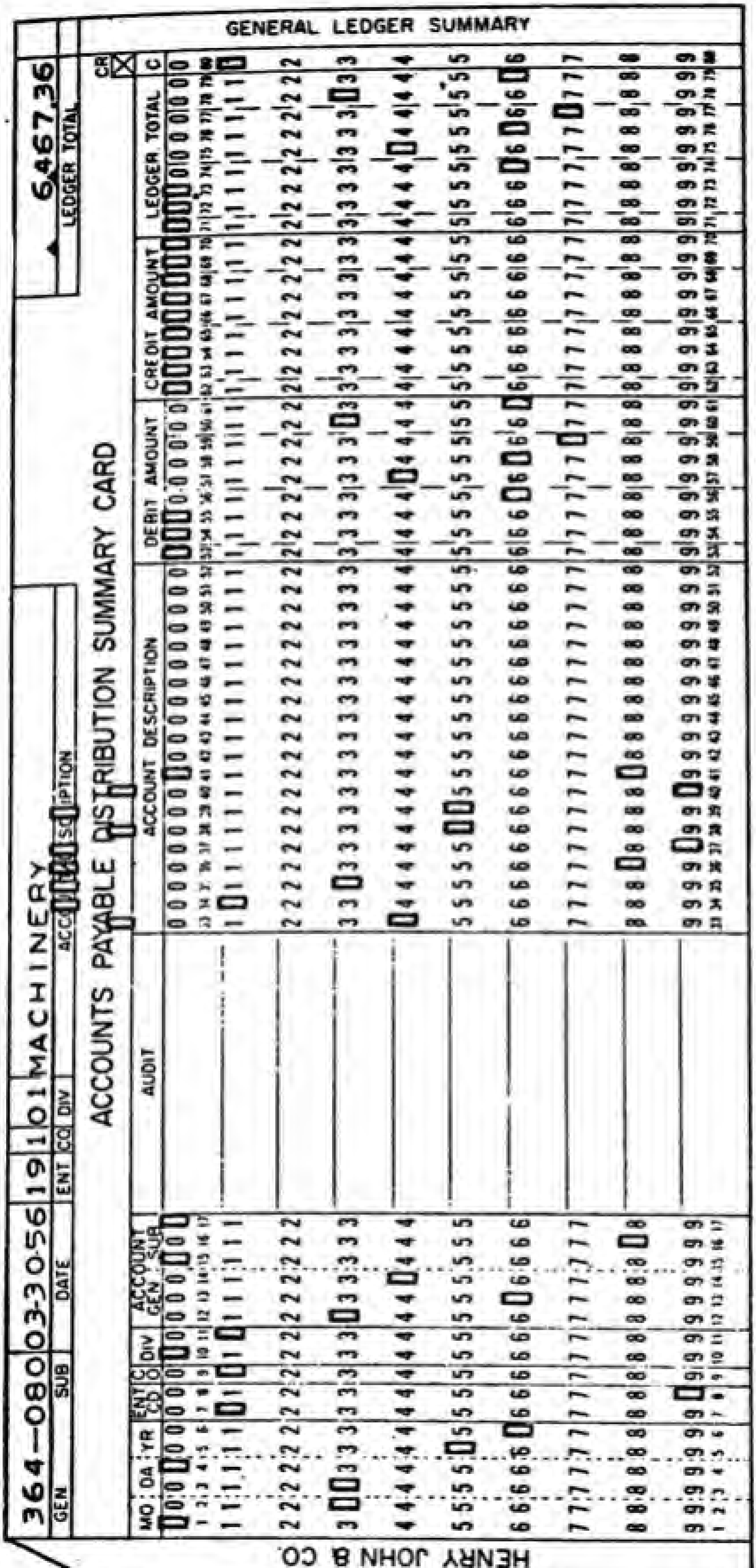


Figure 6. A Ledger Summary Punch Card

attempts were made to use electronic computers for the purpose of solving problems related to industrial management. Within a few years their use has become more and more wide spread. In fact, some of the new methods of production planning (generally known as linear programming) that have been developed in recent years require such computations that it would often be completely unrealistic to consider their application if it were not for the fact that electronic computers are available.*

In recent years, a rapidly increasing number of companies have put electronic computers to use for the purpose of accounting data processing.†

There is a general consensus that the equipment presently available is likely to become obsolete in the near future because of the technical developments expected in the field. There is also a consensus that the use of electronic computers will continue to spread more and more rapidly and that the main obstacle to be overcome will be the lack of trained personnel.

Except for these few points on which there is a general agreement, there is considerable disagreement as to what kind of electronic computers should be manufactured, whether they should be specialized machines or general-purpose computers, how they should be used, and to what extent their use can be economically justified.

What is of interest to us, in this study, is to note that the most recent developments in the field clearly indicate that in the years to come, the use of electronic computers will greatly influence the accounting process and maybe the training of accountants.

As far as can be anticipated at the time this is being written, and on the basis of what is being done in companies that are using electronic computers for the purpose of accounting data processing, we can relate their use to the general principles of the accounting process as previously described. We can consider that their use amounts to the use of magnetic tapes instead of books or cards or punched cards for the purpose of recording accounting data.

This use of magnetic tapes makes it possible to process the data on an electronic machine which is capable of performing automatically

* See hereunder p. 345.

† See *Electronic Data Processing in Industry: A Case Book of Management Experience;* AMA Special Report No. 3, 1955; Kozmetsky, G., and Kircher, P., *Electronic Computers and Management Control*, McGraw-Hill Book Company, 1956; Canning, R. G., *Electronic Data Processing for Business and Industry*, John Wiley and Sons, Inc., 1956; Becker, E. R., and Murphy, E. F., *The Office in Transition*, Harper & Brothers, 1957.

certain operations that otherwise would require the attention of a human being.

In this respect the magnetic tape is very similar to the punched card and the electronic data-processing machine very similar to the punched card-processing equipment.

At the same time, it should be emphasized that the magnetic tape and the electronic equipment open new horizons in data processing because of their inherent superiority over the punched card process. This superiority is essentially due to the following facts:

1. Capacity of storage, beyond comparison with other methods;
2. Speed of processing, also beyond comparison with other methods; *
3. Wide application of the feedback control.

The feedback control by which it is possible to instruct the machine to detect and report any single transaction that does not conform to an expected pattern or to a given standard of measurement is one of the most impressive characteristics of electronic data processing.†

Figure 7 describes the pattern of accounting data processing when using an electronic computer.

The first step consists in programming the process. Each business has its own requirements, but, as a rule, the programming of a large-size electronic computer for accounting operations requires the full-time employment of a well-trained staff of substantial size and it takes a year or more to complete. The programming defines the procedures to be followed, prepares the coding of operations in a language adapted to the machine, and stores the instructions either in magnetic tapes or in the central processing unit of the machine or in both.

The amount of time required for programming a computer of large size is about the time required for designing and installing the machine itself. This machine is almost the equivalent of a small plant requiring its own lay-out, designed in accordance with the specific requirements of a given business and requiring also an adequate source of power and adequate air-conditioned building facilities.

Although actual figures vary with each business, the order of magnitude of the cost of installing and programming a large-size computer is about \$500,000. The same figure can also be given as the approximate order of magnitude of the yearly cost of operation (including equip-

* See Eckert, W. J., and Jones, R., *Faster, Faster:* McGraw-Hill Book Company, 1955.

† See Canning, R. G., *op. cit.*, especially Chapt. 9, "Equipment Characteristics."

ment cost and personnel cost). Smaller computers are, of course, much less expensive.

After the programming has been completed, the equipment is ready for the processing of the selected accounting transactions. Their selection depends of course on the nature of the business. As a rule, the most repetitive transactions are the ones that are being handled on electronic equipment: payroll, sales, cash, material purchases, etc.

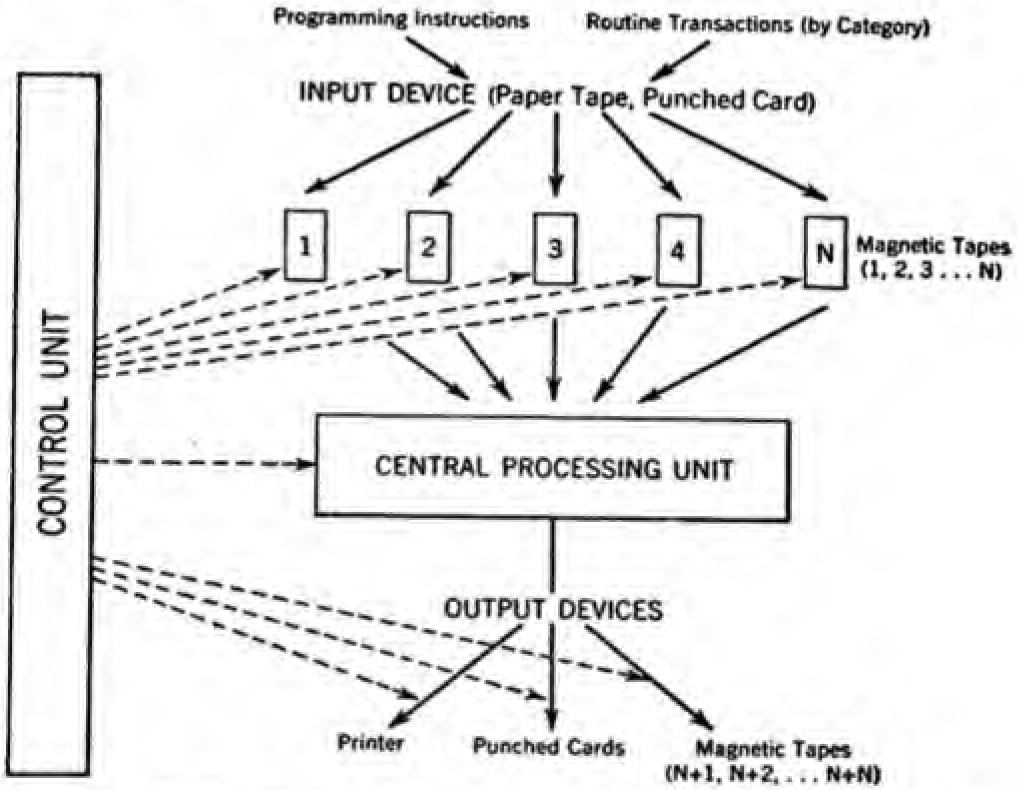


Figure 7. Diagram of Electronic Accounting Data Processing

The original documents are first being recorded on what is indicated in the diagram of Figure 7 as an "input device." This input device can be a paper tape or a punched card. It is used to transfer the recording on a magnetic tape, which is stored and can be considered as the equivalent of the special journal previously described. (Magnetic tapes 1, 2, 3 . . . . n.)

Periodically, these magnetic tapes are being processed on the central processing unit, which can effect computations, re-grouping and sorting in accordance with programming instructions that are stored in its "memory."

The control unit operated by a technician directs and controls the whole processing. Magnetic tapes containing additional programming instructions can also be processed. Magnetic tapes containing standard

information can be combined with magnetic tapes containing information related to actual happenings. For instance, to produce the payroll the tape that has recorded the attendance of the workers is combined with the tape for wage rates, deductions, etc.

After the processing of the magnetic tapes (1, 2, 3 . . . n), the results of the computations, grouping and summarization, are recorded by output devices: printing machines or punched cards or another series of magnetic tapes (n + 1, n + 2 . . . n + n).

Some of the printed reports thus obtained can be considered as the equivalent of the ledger (general or subsidiary) of the traditional accounting process previously described.

The equivalent of the trial balance adjustment procedures, also earlier described, is to be found in the programming instructions which provide for such adjustments to be performed automatically by the central processing unit.

The equivalent of much, if not all, of the human effort involved in checking computations and reviewing every single entry is to be found in the feedback control system also provided by the central processing unit acting automatically on the basis of the programming instructions. This feedback system signals the results that are not in accordance with what can be expected.

This procedure of control can actually be expanded beyond the limits of the accounting process itself. For instance, in a company where the writer had the opportunity of analyzing the programming of the accounting process on a large general-purpose computer, the programming of the sales accounting provides for the recording of information and the performance of computations that are needed for inventory control as well as for those needed for accounting purposes. In this case, when a given sales transaction is being processed, the central processing unit not only computes the total amount of the sales to a given customer. It also computes, for each item sold, the amount of inventory remaining in the warehouse after shipment of the order being processed and compares the amount to the quantity considered as the safety limit that calls for the issuance of a production order whenever it is reached. If the actual quantity left on hand after shipment of the order being processed is equal to or less than this limit, the central processing unit signals the need for ordering the production of this particular item. In such a case, there is an actual integration of various aspects of the control process: accounting process, inventory control, production scheduling.

In concluding this general review of the use of electronic data processing equipment, mention should be made of the fact that the use

of this equipment is likely to have far-reaching consequences upon the organizational structure of the modern industrial enterprise.

The electronic data-processing equipment requires a substantial investment and highly specialized skill, its cost of operation is high, it requires physical facilities that make it an independent unit and, like any other piece of equipment, it reaches its full value only when it is used to the full extent of its possibilities. All these characteristics tend toward the development of a new function within the business, the control function. It is not unlikely that in the years to come, the functionalization of control will gain increasing recognition. Even without giving special consideration to the use of electronic computers the writer has for many years been convinced that functionalization of control is highly desirable and has advocated its adoption: electronic computers make it even more valuable. The functionalization of control, implied in the concept of flexible integration,* means an integration of the control activities, which results from a closer relationship between the functions presently dealing with controlling activities, such as accounting, budgeting, cost control, work measurement, forecasting, production planning, etc. The logical consequence of such an integration is the centralization of control within the middle-sized company or within the limits of the division of the large company. If it is not properly balanced, centralization of control can be the origin of tyrannical bureaucracy. If it is associated with functional decentralization of authority and responsibility, centralization of control can, on the contrary, become the means by which individual freedom and initiative can best be stimulated in modern industry. As aptly stated by Mr. Don G. Mitchell, chairman of the board and president, Sylvania Electric Products, Inc.:

"Electronic data processing is gradually going to force a great many changes in top management's basic thinking . . . One may ask whether, in a company committed to a philosophy of decentralization, the decision to build a data-processing center may not mean a reversal of long-standing policy. Our answer at Sylvania is that we expect this new tool to strengthen our belief in decentralization.

Our definition of decentralization has always been *decentralization of authority and responsibility with centralization of control.*†

* See Villers, "The Concept of Flexible Integration" in *Journal of Industrial Engineering*, July, 1955.

† Mitchell, Don G., Proceedings of AMA's Special Electronic Conference: New York, March, 1955. See also, Villers, *The Dynamics of Industrial Management*, Chapter 10, 1954; and also his "Freedom and Control in a Decentralized Company" in *Harvard Business Review*, March-April, 1954.

II

FINANCIAL STATEMENTS

IT WAS SEEN IN THE PRECEDING chapter that the primary goal of the accounting process is to provide a reliable recording of the flow of values in the business enterprise. It was also seen that there is a fundamental conflict between the auditing activities, which require a very detailed analysis of this flow of values, and the managerial control activities, which require a comprehensive picture of the whole situation. It was shown that the accounting process endeavors to solve this conflict by proceeding first with an analysis of the flow of values, transaction by transaction, and then grouping the transactions by sets of values, i.e., by accounts. This provides a better synthesis of the situation. It results in a listing of all transactions account by account in the ledger. It does not, however, relate the accounts to each other. It shows, for instance, that the cash account amounts to $115,000 and the raw material inventory is worth $76,000, but it does not provide a comprehensive picture of the values of the economic flow. To provide such a comprehensive picture, the

accounting process proceeds with a further grouping of the accounts into two financial statements.

As is always the case when it comes to assembling statistical data by groups, there is room for arbitrary decision in grouping the accounts by categories. In fact, each individual business selects its own grouping. At the same time, there is a well-established tradition in accounting which defines the general pattern to be followed in effecting this grouping. This general pattern, which will now be described, leads to the preparation in traditional accounting of two basic financial statements, the *balance sheet* and the *profit and loss statement*. The present chapter deals with the nature and meaning of the information contained in the balance sheet and the profit and loss statement.

Before entering into such a discussion, it might be helpful to the reader who is not yet familiar with the techniques of the accounting process, to give a brief explanation of the difference between those two fundamental statements. The difference can be best explained by returning to the economic flow chart (Fig. 1, page 10) and by making a comparison with the difference between photographs and movies.

The balance sheet is a representation of the economic flow at a certain time—a picture of it. The profit and loss statement is a description of what has actually happened during a certain period of time as a result of the flow of values—figuratively, a movie of it.

The first is a static document while the second is a dynamic one, both being quantitative analyses, in function of time, of the economic flow of the business. They both relate to the fundamental equation of the economic flow defined in the preceding chapter and which reads as follows:

$$\text{Assets} = \text{Liabilities} + (\text{Income} - \text{Expense})$$

A. THE BALANCE SHEET

1. *General Principles.* A tabular statement of what a company owns, the form in which the property exists (materials, land, machinery) and an estimate of the value of each, together with what it owes and the nature of the obligations is termed a balance sheet. That which is owned is an asset and that which is owed is a liability. The balance sheet is therefore a statement of the assets and liabilities of a business enterprise considered as a legal entity.

In accounting practice, there is some divergence of opinion as to the strict definition of liabilities. Sometimes it includes only what we owe to outsiders, but it often is meant to include also the proprietorship or net worth, i.e., what "we owe" to the proprietors: capital, reserves and

surplus coming from capital or from profit. Table I reflects the latter point of view; the former one is fully discussed in section C, page 57.

As was seen in the preceding chapter, the financial operations of the business are accounted for by the process of recording each single transaction, in books, or on files, or on cards, or in more recent years, on magnetic tapes.

These transactions are subsequently grouped by sets of values or accounts. This is the first grouping. The balance sheet is prepared by further grouping of the transactions. All the assets accounts are grouped in one group and all the liabilities accounts in another group.

The balance sheet may therefore be viewed as a record of the state of a business at a given date, in terms of what the company possesses or owns (assets) and who provided the money or granted the credit (company's liabilities) with which it acquired its possessions. Thus in simple form a balance sheet statement may read as in Table I.

TABLE I

A BALANCE SHEET

We Own (Assets)

1. Money (cash)	$ 10,000.00
2. Promises to pay us (accounts receivable)	20,000.00
3. Materials (inventory)	30,000.00
4. Land	40,000.00
5. Buildings	100,000.00
6. Machinery	100,000.00
TOTAL	$300,000.00
We Owe (Liabilities)	
1. Merchants who sold us materials	$ 20,000.00
2. Bankers who loaned us credit for 90 days	5,000.00
3. Many people who loaned us on long-term credit and to whom we gave bonds	125,000.00
4. Many people who loaned us credit for the life of the business and to whom we gave stock certificates	100,000.00
5. By charging people who bought our goods more than it cost us to produce the goods, we have accumulated	50,000.00
TOTAL	$300,000.00

Thus there is had "an accounting" of the business in terms of how much money and credit is in the possession of the business at a certain date and what kinds of credit instruments were exchanged for the credit extended, together with a record of the use to which this

money and credit were put as evidenced by the kind and value of the property possessed, all expressed in terms of a common unit, the dollar. The statement is termed a balance sheet because the assets and liabilities are balanced. This equilibrium between assets and liabilities is an obvious consequence of the fact that the economic flow of a business proceeds by conversions (see preceding chapter).

The statement of the forms of property possessed, particularly their "values" in terms of the dollar unit, are for the *date* of the statement only. They will be different the next day, and on all days following, because a flux in values is taking place constantly. The nature of this flux in values is as follows: Cash flows into materials, labor, and services; these combine into inventory; inventory flows into accounts receivable; receivables flow into cash. Machinery and buildings flow into inventory by the process of depreciation as a factor in factory expense; inventory flows into accounts receivable; accounts receivable flow into cash. This process was the subject of the preceding chapter.

The same sort of flow occurs with the liabilities and between the liabilities and the assets. Accordingly, it is important in the operation of business enterprise to maintain and regulate this flux in values to conform to the amounts and times of maturity of obligations. The values stated in the balance sheet are "book values" derived by the process of accounting for the use of funds, that is by the process of auditing. They also, as in the case of contingent liabilities, show an estimate of the probable future flow of funds into certain categories of expense and, as in the case of inventory, may show values on the basis of the market prices or materials if and when these are less than the prices paid in acquiring them.

2. *Classification of Assets.* The assets of the balance sheet are grouped in certain categories, as illustrated in the simplified example in Table II.

It will be noted that the assets are listed according to three general classifications, namely: *current assets*, which are assets in the form of cash or items which are readily convertible into cash; *fixed assets*, which are the permanent investments of the business; and *other assets*, which are generally items paid in advance. If these items had not been paid in advance, cash in the case presented in Table II would be $25,000 greater.

There is no standard form of balance sheet in general use, but the items of current assets and fixed assets will usually be found in every balance sheet.

TABLE II

BALANCE SHEET

A. B. Manufacturing Company

New York City
December 31,19–

ASSETS		LIABILITIES	
Current		*Current*	
Cash	$ 100,000	Accounts payable	$ 50,000
Accounts receivable	250,000	Notes payable	190,000
Inventory	650,000	Accrued items	10,000
Total currents assets	1,000,000	Total current liabilities	250,000
Fixed		*Other*	
Plant	2,500,000	Mortgage	750,000
Branch office equipment	150,000		
Automobiles	250,000	*Reserves*	
Investments	600,000	Contingencies	50,000
Total fixed assets	3,500,000		
Other		*Capital and Surplus*	
Unexpired insurance	10,000	Capital stock preferred	1,500,000
Prepaid taxes	15,000	Capital stock common	750,000
		Surplus	1,225,000
Total other assets	25,000	TOTAL LIABILITIES	$4,525,000
TOTAL ASSETS	$4,525,000		

One of the principal duties of the management, as far as the supervision of financial operations is concerned, is to see that the fixed assets of the business, as represented by machinery and plant equipment, are sufficient to produce and handle the requirements of the sales department, and to provide adequate current assets to purchase materials, meet the payroll each week, maintain sufficient inventory, accommodate customers by carrying their accounts for 30 days or more, and discount their bills promptly. The assets of the business may be likened to the defensive and offensive forces of a nation. If a country had all its military equipment in the form of fortifications (fixed assets) it would have no mobile equipment (current assets) with which to carry on its military operations. If all of the capital of a business is invested in plant and machinery, there are no means for providing material, labor, and services to run the plant.

The amount of current assets required for a given business, as well as the investment demanded in the way of fixed assets, will depend entirely on the nature of the business and the volume of sales. There

is a desirable value or a limit for each item of the balance sheet for every business, and any departure from these limits will constitute some hazard to the business. Cash should not run below a given amount. Accounts receivable should not run above a certain limit. Inventory should not be *more* than a stated sum or *lower* than a fixed amount. Investment in plant should not be larger than required for sales demands.

Every manager should know these limits for his particular business and direct its affairs so that each item of the balance sheet reflects a healthy situation and does not become a source of hazard.

There are three principal divisions of the current assets:

a. *Cash*, which is composed of deposits in the bank, money in the hands of agents, petty cash in the office, and money located at other authorized places. A carefully supervised budget of income and expenditures, which provides for the maintenance of a good cash reserve, is a very important factor in business.

b. *Accounts receivable*, to be perfectly frank, represent the amount by which the manufacturer is acting as a banker to his customers. Carrying customers on open account may result in quite a hazard, and therefore this item should be very carefully managed.

Accounts receivable representing over 30 days' business indicate a too liberal credit policy. If, for example, a company does a business of $1,000,000 per month, and its accounts receivable are $2,000,000, it indicates that some customers have not paid their bills for 2 months or more and are likely to become delinquent.

c. *Inventory* represents the money value of direct labor, raw material, and factory expense accumulated in finished goods and goods in process. Inventory is frequently given as valued at "actual cost,"* or the market value, whichever is lower. What this means is that in an appraisal of assets the drop in the market price of raw materials, if any has occurred since the material was purchased, has been taken into account. In judging the value of assets, considerable attention should be given to the inventory items. Very frequently the values given are deceiving. Suppose, for example, that an inventory has been accumulated with the factory running at 25 percent of normal capacity, and resulting in a factory expense of 250 percent on labor, while, with 100 percent factory operations, the factory expense may be only 100

* "Actual cost" may be determined by various methods such as *LIFO*, *FIFO*, etc.

percent on labor. An inventory value based on 250 percent factory expense would not be fair. The writers recall a very troublesome appraisal in which the above situation was encountered. The management of the inventory item in the operation of any business must be conducted with special care, for reasons which will be referred to subsequently (see Chapter III).

It is frequently found that, owing to changes in manufacture, or for other reasons, material which once had value is no longer valuable because it cannot be disposed of. Accordingly, the inventory should be divided into three general groups:

(1) Current
(2) Slow-moving
(3) Obsolete.

Current inventory (1) is that which is applicable to current sales and may be disposed of at a profit within a reasonable time. *Slow-moving inventory* (2) is that which applies to orders which are received only occasionally or to repair parts for which there is an occasional call. It cannot be disposed of in the near future and may also have to be disposed of at prices much lower than inventory values. Such inventory items are written down in value by a conservative management. *Obsolete inventory* (3) is that which applies to goods for which there is no demand and which, as such, have only scrap value. If such inventory has not been written down but is carried on the books of the company at acquired cost, the inventory is inflated.

From the above statements it is evident that estimates of inventory values may vary widely and are often subject to question.

d. *Fixed assets* is sufficiently clear in meaning. Attention is called, however, to two different ways of reporting this item. It is sometimes the practice to report the original purchase price or the appraised value of the plant and equipment without deducting for depreciation each year, but carrying a depreciation reserve on the liability side of the account. Others deduct the depreciation each year and report the net value as assets. Care should be exercised in reading this item to note whether adequate depreciation has been allowed.

e. *Other assets* refers in general to those items of assets which cannot be classed as current because they will not be soon converted into cash; or fixed, because they are not a part of the operating equipment. Among such items may be prepaid items, such as insurance; invest-

ments in subsidiaries; investments in other properties, such as housing for employees not used directly in the business; and other items of the same nature.

3. *Classification of Liabilities.* The *liabilities* are the obligations of the corporation. They also disclose the sources of funds through which it has been possible to acquire the assets. These funds are furnished by two general groups—the creditors and the owners. Among the creditors there are two general classes: short-term and long-term. The obligations to short-term creditors are known as the current liabilities; those to long-term creditors are variously listed in terms of the documents of indebtedness they hold.

a. *Current liabilities* are those incurred through materials purchased on open accounts, bank loans on short-term notes, and services and supplies furnished on credit. It is generally assumed that current account items will be paid within 30 to 60 days. The current liabilities may also contain *accrued items* which are payable at stated periods and have accrued to date to the amount stated in the balance sheet. Such items may relate to insurance and taxes. Again, if wages are paid on a Friday and the balance sheet happens to be drawn up on a Wednesday, the wages accrued in the interim also appear under the heading of accrued items.

b. *Other liabilities* are those on which payment is due at a distant date. If, for example, money has been received on mortgage, the mortgage may be payable in 3 years or 5 years. To facilitate the raising of funds from a large group of people, a company may issue notes of \$1,000 or other denominations, which notes are secured by a mortgage. For example, a company may sell 1,000 notes of \$1,000 each, the total amount of which may be secured by a mortgage on property worth \$2,500,000. The interest payable on these notes is usually due semiannually. Assume that they are due January 1 and July 1. Thus, on March 1, there should appear among the accrued items an amount of \$10,000 on account of 2 months' interest on \$1,000,000 at 6 percent accrued. On May 1, this will amount to \$20,000 and should be transferred from accrued items to current liabilities because it is due and payable within 60 days of that date. These same remarks apply also to partial payments, if any, required to reduce the mortgage on specified dates. Accounting for such liabilities may, however, be made through setting up reserve accounts, but it is believed to be better practice, that is, the authors believe it to be better, to account for such payments due as above set forth.

c. *Reserves* are items set upon the balance sheet to account for payments which may have to be made at some future date on account of certain obligations contingent on the business. Reserves represent withdrawals from surplus. For example, if a suit should be brought against a company on account of alleged patent infringement, the defense of this action requires funds. The directors may estimate that it will cost $50,000 to settle this matter (their estimate may be wrong), and they will direct that a reserve, on account of this suit, of $50,000 be set up. Setting up this reserve is a way of stating that some day the company may have to pay out at least $50,000 because of this suit.

If dividends on preferred stock are accrued but not payable for some months, a reserve on account of dividends accrued may be set up. A reserve for depreciation may also appear in this list. Since a reserve account indicates the probability of payment of cash at some future date, it is obvious that the treasurer of the company must control his cash resources with some regard to the possibility of such payments. There should, therefore, be some rational relation between the amount of reserves and cash on hand. Sometimes cash to the total amount of the reserves may be withdrawn from the general funds and put into a separate bank account. If the company is not in funds and the payment anticipated as expressed in the reserve eventuates, the company may be embarrassed if it cannot negotiate a loan to meet the payment when due. A reserve does not mean much unless represented in cash, for a simple withdrawal of an amount from surplus (on paper) and transfer to a reserve account does not provide the cash.

d. *Capital stock* is a liability of the company to certain individuals who have advanced funds to be used at the risk of the business. The evidences of such indebtedness are the stock certificates. These certificates in general state that the ones to whom they are issued have certain specified rights with respect to earnings or payments of cash upon liquidation of the business or otherwise. Not all stock certificates are issued for cash, nor are all certificates of a definite par value. In general, there are two classes of stockholders: Those who hold preferred and those who hold common stock.

Preferred stock is so termed because it is preferred as to earnings and may be so as to assets. Not all preferred stock certificates are alike, any more than all contracts are alike. Preferred stock is an agreement between the company and the holder, and its value depends on what has been agreed upon and the ability of the company

to meet the terms of the agreement. Among the terms which may be agreed on are:

(1) The preferred stock shall have the first lien on earnings before the common stock.

(2) The earnings are fixed and payable at stated periods. Thus a preferred stock may bear dividends at seven percent of its face value, payable annually.

(3) It may be cumulative, and therefore the dividends specified are obligations, even though they may be deferred.

(4) It may have no voting rights unless the dividends are not paid for a certain period of time after they are due. If the bylaws of the company provide that there shall be a board of directors of nine members, the preferred stockholders may elect the total of nine or only five or maybe three, as the case may be, if the dividends on the preferred stock are passed. Sometimes this right is not provided for.

(5) It has certain prior rights over the common stock upon liquidation or sale of the business. If, for example, a business is sold for \$800,000 and the preferred stock outstanding is of the par value of \$1,000,000, then the holders of preferred stock may be paid 80 cents on the dollar and the holders of common stock get nothing.

Common stock of a company in addition to title of ownership is in general a right to earnings when, as, and if declared as dividends by the directors. Common stock certificates may have a par value or may be of no par value. When a company sells no-par-value stock, the price at which it is sold by the company is determined by the board of directors under regulations fixed by the bylaws of the state granting the company's charter. Thus a no-par-value stock may be sold for \$10 or \$5 per share, or for other amounts. It may also be issued for services or other valuable considerations. It may pay dividends of \$10 per share or \$100 per share or any other amount, according to the earnings of the business and what the directors may specify to be paid. In declaring dividends, the directors are limited by certain statutory laws and should be guided by good business judgment. Dividends are payable out of surplus. If a company has a surplus of \$500,000, even though the earnings for the past year were nothing, the directors *may* declare a dividend of \$100,000 or \$200,000 or other amounts on the common stock, or they may declare no dividend if they feel that the money is needed in the business. If a company has

a deficit of, say, \$500,000, no dividend can be declared, even though the earnings for the past year may have been \$1,000,000.*

Sometimes two classes of common stock will be encountered—a Class A and a Class B. It may be provided that Class A has all the voting rights and Class B none. It may also be provided that Class B shall have a dividend of a certain amount before Class A can participate in the earnings. The purpose of this provision is to centralize the voting control within a small group of stockholders, usually the originators of the enterprise.

The money value of the common stock stated in the balance sheet should be just what was paid to the company upon its issuance. If, for example, a company had issued at one time 500 shares of no-par-value common stock for \$10 a share and at another time had sold 1,000 shares at \$12 per share, the balance sheet should show an item of

$$\text{Common stock} = \$17{,}000$$

e. *Surplus* is that amount which is owing the stockholders in addition to that which is owed them on account of the book value of their stock certificates. Surplus does not represent cash, but is simply an account of indebtedness of the company to its stockholders. If, however, the directors encounter a situation for which they believe a reserve should be set up and the reserve is set up by proper authorization, then the indebtedness of the company to its stockholders is thereby automatically reduced by the amount of the reserve because the procedure in such cases is a transfer from surplus to a reserve. If the conditions because of which the reserves were set up disappear, and no expenditures were made from the reserve, it may be transferred back to surplus.† Earned surplus (from which dividends may be declared) is derived from the earnings of the business. Capital surplus is derived from the sale of stock at a premium, and from a write-up of assets.

4. *Value of Assets and Liabilities.* The values of the asset items and the liability items of the balance sheet are based on either money transactions or on estimates. For example, when a machine tool is purchased for \$5,000, its value in the books of account is recorded as \$5,000. If a duplicate of the above machine (new) should be purchased a few months later at a bankruptcy sale, for \$3,000, its value

* The deficit at the end of the preceding year would have been \$1,500,000.

† The distinction between *reserve* and *surplus* is therefore very definite. In practice, however, some confusion may arise due to an unjustified but extensive use of the word "reserve." (See page 51 concerning the *net worth* of the business.)

would be recorded as $3,000. Some accountants may add the freight charges and placement costs to the "value" of the machine as an asset, while others may absorb the freight and placement costs in current expenses. The value of the inventory of goods manufactured at the plant contains a charge for depreciation of the assets used in their manufacture. This charge is based on an estimate of the useful life of the assets used. If the estimate of the useful life is 5 years, the depreciation charge is twice as great as if the useful life of the assets used is estimated to be 10 years. If a given raw material is purchased at 20¢ a pound, the raw materials inventory will reflect this fact. But if, at the end of the year, there should be 10,000 pounds of this material on hand and the current market price is 15¢ the pound, then the auditors of the company's books will "write off" $500 from the inventory to reflect current market price. However, if at the end of the year the current market price of above material is 25¢ a pound, this increase of 5¢ a pound would *not* be added to the value of the inventory.

Liabilities are expressed in dollars and cents in an attempt to state the amount of money which may have to be spent or paid out in meeting certain obligations when they become due. Certain liabilities can be very definitely expressed; others cannot. For example, a threatening patent suit establishes a contingent liability because of the expenses for defending it. No one can tell what these expenses may be. Reserves may be set up in the balance sheet as an expression of the probable amount of money which may have to be paid out if certain contingencies occur. Perhaps, when lawsuits are pending, no reserve has been set up. Does the balance sheet show all values of liabilities?

B. THE PROFIT AND LOSS STATEMENT

Definitions. A financial statement of the results of conducting a business for a given period of time (usually a month or a year) is termed the profit and loss statement. A simple form of such statement is given in Table III.

The items of the profit and loss statement are to be interpreted as follows:

Sales means actual billings to customers for goods shipped during the month. Sales are not orders, that is, an order does not become a sale until goods are shipped and billed to the customer. Thus a company may have received $1,256,520.16 of orders during the month, but if it has only shipped $971,250.16 during the month, the sales are the latter amount.

TABLE III

PROFIT AND LOSS STATEMENT

A. B. Manufacturing Company
For the Month of January, 19–

Sales		$857,393.22	
Discounts and allowances		1,116.40	
Net sales		856,276.82	100 %
Cost of sales			
Labor	$242,986.10		
Material	157,321.16		
Factory expense	209,110.09	609,417.35	71.1%
Gross profit		246,859.47	28.9%
Administrative expense	24,732.07		
Selling expense	76,117.22	100,849.29	11.7%
Operating profit		146,010.18	17.2%
Other income		216.14	
		146,226.32	
Other expenditures		1,513.20	
Net profit		$144,713.12	16.9%

Allowances are deductions from billed price to customers on account of returns of goods for any reason. *Discounts* from billed prices may be allowed for prompt payment or other reasons.

Net sales then represents the actual sum of money which has been or may be expected to be received for goods sold.

Cost of sales is a term current in accounting practice and means the cost of manufacture of the goods sold.

Labor means the direct labor cost of the goods.

Material means the direct material cost of the goods.

Factory expense means that portion of the cost of possessing and operating the factory which is properly chargeable to the goods sold.

Gross profit, the difference between net sales and cost of sales, is the profit realized before administrative and sales expenses have been deducted.

Administrative expense and *selling expense* together constitute the *general overhead* of the business.

Operating profit is that profit which is realized from the operations of the business proper and exclusive of subsidiary operations from which arise other income and other expenditures.

Net profit is that sum which is added to the surplus of the business and as such is available for dividends and other corporate expense.

Particular attention is called to the fact that the expenditures and profits just indicated are only those which obtain for a given volume of sales and for a given plant output, and by no means should any such percentages or ratios be taken as constant for a wide range of sales. A great error will be made in forecasting the probable earnings of the business if it is assumed that the net profits on *all* sales will be 16.9 percent, as the above data show to be the case only for a given volume of business done at a given time.

The monthly profit and loss statement is supposed to constitute a record of the results of the economic performance of a business for a given month. This is not strictly correct. The statement records the results on the *business concluded* during the month. In the first place, as was noted above, the basis of the record is sales for the month, that is, goods shipped and billed to the customer. The orders for the goods shipped may have been booked the preceding month or several months before. Therefore, it may happen that the orders booked for the past several months may actually be declining and yet the sales as recorded in the profit and loss statement may be showing an increase during the same period.

The "cost of sales," or the cost of manufacture of the goods sold, may not have been incurred during the month to which the profit and loss statement relates. In fact, the costs recorded may have been incurred many months before. In the manufacture of typewriters, for example, it is common practice for certain lots of small parts to be manufactured in quantities sufficient for several months' supply because the set-up time of the presses constitutes a large portion of the cost of processing and, hence, it is more economical to produce a large quantity per set-up and store the parts for subsequent assembly. The cost of the lot thus processed will be made up as to materials, labor, and factory expense (estimated) and divided by the number in the lot to determine the cost per unit. When the part is withdrawn from semifinished stores for assembly at a later date, the cost is accrued to the lot of machines assembled, and when any of this lot of assembled machines is shipped at a still later date, it is this cost which was incurred some time before, which finds its way into the record cost of sales. Accordingly, the record "cost of sales" in the profit and loss statement does not necessarily show the expenses either paid for in cash or incurred during the month on account of goods manufactured

in that month. Assume, for example, that a factory is shut down for vacation in August of any year and that there is no production. Assume that the order and shipping departments, however, are not on vacation—so that customers' requirements may be attended to. Accordingly, the "sales" for August may be $500,000, say, and the profit and loss statement for the month may show a cost of sales of $350,000, yet no expenditure was incurred during the month for direct labor.

The same situation exists in regard to administrative expense and selling expense. A company may order a year's supply of catalogues, for example, and pay for them in the fall, yet it may be decided to apportion this expense to each month of the following year, in which case part of the selling expense recorded in any month may relate to an actual expenditure made several months prior.

Thus it will be apparent that the monthly profit and loss statement of a company may not indicate its current performance in the matter of either expenses incurred or orders booked. It should be noted also that none of the items of the profit and loss statement indicates cash transactions. In the above statement, in which the net profit is shown to be $144,713.12, it is not to be inferred that the company has increased its cash during the month by the amount of the profit. Profit has no relation to the cash position. In fact, it may happen that a company showing a net profit of $144,713.12 in a given month may have less cash at the end than at the beginning of the month.

C. PROPRIETORSHIP

The inclusion of a condensed profit and loss account in the balance sheet statement under the heading of *Proprietorship* is advocated by such an authority as Dr. Roy B. Kester, Professor of Accounting, School of Business, Columbia University.* It has considerable merit from the standpoint of clear statement. According to this method of statement, a balance sheet would appear as in Table IV.

This form of statement shows at a glance the principal facts of a business, particularly as to the changes in proprietary interest. The profit and loss statement is in the usual form, though in such a case it is a kind of exhibit to the "proprietorship" section of the balance sheet.

Another important aspect of this kind of presentation is a clearcut division between the liabilities, strictly speaking, i.e., what the business owes to outside creditors and the liabilities of the business to-

* Kester, Roy B., *Principles of Accounting*, 4th Edition, Ronald Press, 1939.

TABLE IV

BALANCE SHEET

—— Corporation
August 31, 19–

Assets		
Cash	$ 148,968.48	
Accounts receivable	217,930.47	
Inventory	288,888.62	
Plant (less depreciation)	1,314,378.26	
Deferred items	35,186.24	
Patents	949,880.04	
TOTAL ASSETS		$2,955,232.11
Liabilities		
Accounts payable	38,275.89	
Accrued expenses	16,830.41	
Other items	68,891.44	
TOTAL LIABILITIES		123,997.74
Proprietorship		
Capital stock	2,000,000.00	
Earned surplus	818,382.12	
Net profit for month	12,852.25	
TOTAL PROPRIETORSHIP		2,831,234.37

wards its owners, i.e., the proprietorship. Such a division gives the balance sheet a greater clarity. The immediate consequence is that the fundamental equation of accounting

$$\text{Assets} = \text{Liabilities}$$

is changed into the equation

$$\text{Proprietorship} = \text{Assets} - \text{Liabilities}$$

Thus the net worth is immediately revealed.

D. DEFINITION OF TERMS USED IN READING THE FINANCIAL STATEMENTS

Some of the items of the balance sheet or of the profit and loss statement are often grouped together to give further meaning to the statements. Among them, the following are most used.

1. The *net worth* of a business is the sum of the capital stock issued and the surplus. It represents the amount which the stockholders have in the business.

If the balance sheet is presented in three parts, the net worth is equal to the total of the proprietorship section (see above, page 58). It may happen, however, that, in good logic, part or all of the *reserves* should be included in *net worth*. This is the case if and when the so-called reserves are, in fact, surplus that are accounted for under the name of reserves. In case of doubt, one should consider the nature of an item rather than the name it is called by.

2. The *debts* of a business represent the amount which the creditors, both long-term and short-term, have at the risk of the business. The sum of net worth, debts, and reserves constitutes the total liabilities.

There are, therefore, two groups of interests which provide capital to operate a business—the stockholders and the creditors. The creditors are also of two classes, i.e., those whose accounts are payable over a period of years, and the short-term creditors who are generally merchandise creditors, banks, and note holders. The long-term creditors are generally those who hold mortgages or bonds.

The management of the finances of a business should be so conducted that there are always sufficient funds on hand to meet its obligations. Accounts receivable should be turned into cash in anticipation of maturing obligations. If current bills are not paid on time, the credit of the organization is impaired and a serious handicap is placed on the conduct of the business.

When accounts receivable are not collectible, as perhaps in a general business depression, the assets of the company are said to be frozen. Creditors press their claims, and the company may be forced into bankruptcy or a receivership to protect its assets. The same situation arises when mortgages must be met and no funds are available to meet them. This condition is very frequently due to poor financial management, in which investments are made in plant extensions to provide improvements or in anticipation of new business, and the new business never materializes. Sometimes large purchases of raw materials are made well in advance of immediate requirements and the bills for these materials must be met before they can be converted into goods and sold. If the market has been misjudged and if bank loans cannot be made to tide over the situation, the company is likely to become embarrassed.

3. The *working capital* of a company consists of the current assets less the current liabilities. Bank loans, if any, should be included in

the current liabilities. Banks generally will renew a note upon partial payment of the principal when due, but it is generally true that the bank will require the borrower to be "off its books" at least once a year. Furthermore, since the bank must be careful not to extend itself it may be forced to call a loan or demand payment upon maturity. Therefore, it is well to assume that bank loans are current liabilities to be paid within a short period of time.

4. The *capitalization* of a corporation consists of the par value of both the common and preferred stocks which have been issued, plus the face value of the bonds issued. This term is not always clear for the following reasons. If a bond issue is about due for retirement, either in whole or in part, it certainly cannot be considered a permanent investment. If the common stock is of no par value and yet has been sold for a considerable sum of money, this sum does not appear as part of the capitalization. The term has doubtful value.

5. The *capital structure* of a corporation refers to the total funds invested in the business by the bondholders and the stockholders. The stockholders' investment consists of the amounts paid for the stock, either par or no par, and the amount of earnings left in the business through accumulated earnings (surplus) and the capital surplus, if any. This is a changing item due to bond retirements and the declaration of dividends out of earned surplus.

E. CONCLUSION

The principal features of the balance sheet and the profit and loss statement are, as noted above, general records of the state of the values of a business at a particular time and the changes in values which have occurred during stated time periods. The usefulness of these statements as guides to company policy depends, in part, on the *relationships* which these values have to each other and to the operating characteristics of the particular business to which they relate. Accordingly, some interpretation of the relationships between the items of the financial statements must be made. Among these relationships, those known as balance sheet ratios and operating ratios have been generally standardized, and it is now our purpose to define and interpret them.

III

INTERPRETATION OF FINANCIAL STATEMENTS

BALANCE SHEETS and profit and loss statements represent an accounting to the stockholders of the uses made of the funds they have invested in the business. Bondholders and other creditors, particularly commercial banks, are also informed, through these statements, concerning the uses of the funds which they have loaned to the business. The financial statements are certified by authorized public accountants as a guarantee to all those who have put any money into the business, that all funds are properly accounted for. But certain important facts about the business, particularly its stability and the skill of the management, must be determined through a detailed interpretation of the items of these statements. What is meant by an interpretation? It means to give meaning to. Data of themselves convey very limited meaning. They have real meaning only when they are related to or compared to other data. By relationships and comparisons we may determine or measure variations in time, variations in status, variations in performance and

variations from a standard. Thus financial statements supply mainly the raw data which, together with data from other sources, need to be arranged, compared, and measured in order that such statements may yield the information required for policy formation and determining a course of action. A number of methods of comparison and measurement of performance for devising the status and changes in financial values are in common use. These are based on three principal sources of data:

A. Financial ratios
B. Predetermined standards
C. Supplementary data from other company records.

These methods, which we will now examine, are mainly statistical in that they reveal *how* and not functional so as to tell *why*. The functional method of analysis will be developed in following chapters.

FINANCIAL RATIOS

A financial ratio expresses the relationship between items of the financial statements. A comparison of these ratios among themselves is used to portray certain aspects of a business.

It is very important for the manager of any business enterprise to know the acceptable values which each of the ratios should have for the particular business that he is managing.* These ratios are not constant for all businesses; that is, a ratio which indicates a healthy condition in one business is wholly inadequate for another business. Therefore, these ratios are not to be considered as absolute measures but as *indicators*, which, together with other factors, show the general status of the business. In general, the ratios are useful in revealing certain aspects of the business, relating to:

1. The financial structure
2. The financial management
3. The efficiency of operations
4. The result of operations.

1. THE FINANCIAL STRUCTURE

A business may acquire its finances through the stock subscriptions of its owners, the reinvestment of its earnings, and loans by its creditors. The owners and the creditors of different classes both have an interest in the business, but the nature of this interest and the rights and obligations of each are not the same. The proportions in which these interests exist are significant as to the financial structure, par-

* An approach to this problem is discussed in the Appendix at the end of this section.

ticularly its stability, and the earnings accruing to the different classes of owners. Among the indications of the above nature are:

a. The Ratio of Net Worth to Total Assets. This ratio shows the extent to which the stockholders own the business. From one standpoint, it is good business to borrow money at 4 percent and utilize it in a business at a profit of 20 percent. The difficulty in such a situation is that the creditors from whom money is borrowed are generally secured by instruments which permit them to take drastic measures in case of a default in payment of interest on loans, or the payment of the loan at maturity. It is because of this hazard, by which creditors' claims may become pressing and embarrassing, that it is not well to have too large a proportion of the capital in the business supplied through such sources.

Now, the question in any given business is: How much is too large a proportion? The answer is that there is no general rule, but that the situation should be carefully guarded. The interests of the owners, plus the interests of the bondholders, is termed the *capital structure*, since the funds derived from the owners and the long-term creditors are more permanent in nature than the funds derived from bank loans, short-term notes, and merchandise credit.

The percentage of each class of owners' shares and the bondholders' shares to the total capital structure determines the degree to which the common stock holdings are conservative or speculative. Professors Guthmann and Dougall report the results of a study they made in the combined capital structures of industrial, utility, and railroad corporations, as in Table V.*

TABLE V

CAPITAL STRUCTURES (A)

	Industrial		Utilities		Railroads	
	$ Billion	%	$ Billion	%	$ Billion	%
Bonds	18.9	13	13.3	41	8.7	38
Preferred stocks	9.7	6	2.6	9	1.9	8
Common stocks	42.5	29	11.0	35	6.1	26
Surplus	77.9	52	4.4	15	6.4	28
	149.0	100	31.3	100	23.1	100

They also report a similar analysis of different types of businesses, in Table VI following.

* Guthmann, H. G., and Dougall, H. E., *Corporate Finance Policy*, Third Edition, 1955. Prentice Hall, New York.

TABLE VI

CAPITAL STRUCTURES (B)

Type of Business	Total Capital Structure (*Millions*)	Percentage Bonds	Preferred	Common & Surplus	Total
Autos and Trucks	$ 6,939	3	6	91	100
Chemicals	10,238	11	8	81	100
Food Products	8,979	14	8	78	100
Machinery	9,210	9	6	85	100
Metals (mining)	1,739	5	3	92	100
Metals (manufacturing)	10,490	13	8	79	100
Motion pictures	1,728	27	3	70	100
Petroleum	16,775	14	2	84	100
Rubber	1,779	20	12	68	100
Textiles	6,691	8	6	86	100
Tobacco	1,945	31	12	57	100

The records show that there is a wide variation in practice as to the composition of the capital structure among different types of businesses. The important meaning of the composition of the capital structure to the investor may be illustrated by the following example:

Let us assume that a company, in a given year, earns $1,000,000 on a capital of $5,000,000. Its earnings would therefore be 20¢ per dollar of capital invested. Assume, however, that the company has a capital structure similar to that of the tobacco industry, as given above, and that the bonds bear 5 percent interest and the preferred stock 7 percent cumulative dividends. In that event, the total bond interest payable would be $1,550,000 \times 0.05 = \$77,500$; the preferred dividends payable would be $600,000 \times 0.07 = \$42,000$; and the common stock would be entitled to the remainder, or $880,500. Assuming, for purposes of illustration, that 50 percent of the common stock plus surplus is common stock, then the amount of common stock would be 28.5 percent of $5,000,000, or $1,425,000, and it would then earn at the rate of

$$\frac{880,500}{1,425,000} = 61.7\%$$

If now the company had its capital structure similar to the autos and trucks industry, and its common stock was also 45½ percent of its capital structure, then for the same rates of bond interest and preferred dividends as before the amount of bond interest would be $5,000,-000 · .03 · .05 = $7,500; the preferred dividends payable would be

$5{,}000{,}000 \cdot .06 \cdot .07 = \$21{,}000$; and the earnings on the common stock would be $\$1{,}000{,}000 - \$7{,}500 - \$21{,}000 = \$971{,}500$. Since the common stock is 45½ percent of $\$5{,}000{,}000 = \$2{,}275{,}000$, the percentage earned on the common stock would be

$$\frac{971{,}500}{2{,}275{,}000} = 42.6\%$$

Accordingly, while each company may earn 20 percent on its capital, the common stockholders, in each case, would fare quite differently, according to the details of the capital structure. In the above examples it was assumed that 50 percent of the common stock plus surplus was common stock, and the earnings on the common stock were determined accordingly. But, since the surplus is also owned by the common stockholder, it appears that in this case his investment in the business is really twice as great as the book value of the stock. Therefore, the real percentage earnings of the *investment* of the common stockholder in the above example is half the percentages stated.

b. The Ratio of Net Worth to Debt (also called *The Ratio of Stockholders Equity to Debt*). This ratio shows another characteristic of the financial structure and reveals the extent to which the creditors (both long-term and short-term) and the owners have each contributed to the funds used in the business. If, for example, in a given manufacturing business the debts should amount to \$3,450,000 and the net worth should be \$3,000,000, the ratio is 87 percent. This means that for every dollar the owners supplied, the creditors supplied \$1.15. Because of the nature of creditors' claims on the assets in case of defaults in payment of their claims, the above ratio represents an unstable and hazardous structure.

In the utilities and railroads, the bonded debt is relatively high because of the control which the public authorities exercise on the issuance of their securities which restricts stock issues. Also, because of such control and supervision, a large funded debt is not considered a hazard to the financial structure.

c. The Ratio of Corporate Funds from Internal Sources to Total Corporate Funds. This ratio is quite frequently referred to in banking circles and is coming to have more meaning in evaluating the financial policies of corporations.

Funds from internal sources are those which are derived from earnings and depreciation accruals as well as from profits on the sale of fixed assets and investments, tax refunds and renegotiation receipts. This fund is lessened by cash dividends and net decreases in cash

balances, marketable securities, trade notes, accounts receivable, inventories, and in other assets.

Funds from external sources are derived from credit advances by banks, by suppliers of merchandise on open accounts or trade acceptances, by bond and noteholders. It may also be augmented by the issuance of additional capital stock.

The total corporate funds are those derived from both internal and external sources.

The ratio of corporate funds from internal sources to the total corporate funds is an expression of management's policy in the creation of the capital structure of the business and in financing its current needs. It measures, in fact, the degree of financial independence of management from the various creditors *and* from the stockholders. The size of this ratio, as of the other ratios previously considered, varies widely among businesses.*

2. THE FINANCIAL MANAGEMENT

The life of a business is always subject to the skill with which its finances are managed. Even though a particular business may be operating satisfactorily as to production, costs and profits, these characteristics alone are not completely indicative of its management. The elements of its financial status must be in satisfactory balance with one another to assure a strong financial condition. The financial management may therefore be judged by the relationship between the items of the financial statements. The following ratios serve as such indicators.

a. *The ratio of current assets to current liabilities* is generally considered to be an indicator of the ability of the company to pay its current debts promptly. In passing judgment on this ratio in any given case, care must be exercised on the following matters. Since current assets are made up principally of cash, accounts receivable, and inventory, it can readily be seen that a company having current assets mainly in cash is in a far different position from one having current assets mainly in inventory of raw materials in great excess of current requirements, although both companies may have the same ratio.

b. *The "acid test,"* which is the *ratio of current assets less inventories to current liabilities*, partially answers this objection, by eliminating the inventory factor. But, still, it is evident that a company having

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* Current information on the subject is made available periodically by leading journals; see, among others, *Federal Reserve Bulletin*, June, 1948, and June, 1954.

receivables which are long past due cannot be said to have a current asset which is readily converted into cash. Therefore, the acid test by itself is not a conclusive indicator of a company's current position.

c. *The ratio of receivables to annual sales* may be helpful in this respect, since it measures the care with which credit has been extended and the diligence of the officer responsible for collections. (More precisely, the average collection period, or the average number of days necessary to collect from customers, is equal to the above ratio, receivables to annual sales, multiplied by 360.)

It is current business practice to pay all bills within 30 days. A discount for payment within 10 days is usually allowed. Incidentally, it may be noted that the allowance of such discounts is generally an expensive method of collecting accounts.

If a company has more than 30-day business in its accounts receivable, it is generally a sign of weakness in the credit and collection departments. This, however, is not always so. Sometimes it is necessary to extend long credits. In the sale of fertilizer to southern farmers, the material is delivered in the spring and planters' notes are given for payment when the cotton is ginned in the fall. If the cotton crop is not good, the notes are not paid in full. In the automobile business it was found prohibitive to extend long credits, because it required altogether too much working capital, and so credit or finance corporations were formed to handle the purchasers' notes. However, one of the great economic problems facing us is the direction of credit to production channels and the restriction of credit to those who are inclined to live beyond their incomes. It is so easy to buy goods on the instalment plan and finance purchases through discount houses that the people in general are mortgaging their earnings too far in advance. There is consequently a false stimulus to business which is sure to have a bad reaction. For a business which deals with a wide market, the ratio of receivables to annual sales should not be greater than about 10 percent, but for businesses which deal with a seasonal market there is generally a tendency to extend credit and the ratio may be higher and yet conform with good business practice. However, it is not to be forgotten that the longer the credit the greater the hazard

Finally, to give full meaning to the above ratios, weight must be given to the nature and size of inventory, and to the state of the individual accounts receivable.

d. *The ratio of cash to current liabilities* establishes the cash position of a company. If a large quantity of merchandise or material is purchased for conversion into salable products to be marketed at a

distant date, as in the case of a seasonal business, cash income will be deferred and, therefore, a higher ratio is desirable, because bills must be met before money is received from the sale of the product. Such situations must be analyzed and set up in the form of a budget of income and expenses before one may be assured that adequate cash is provided to meet current bills.

The ratio *cash and negotiable securities* (or *cash and U.S. Government securities*) *to current liabilities* is sometimes used instead of the above ratio or in conjunction with it.

e. *The ratio of reserves to total assets* is not a particularly significant ratio without some information regarding the peculiar hazards of the business.

In general, a reserve item is a withdrawal from the surplus account in anticipation of an expenditure which events indicate may have to be met. Reserves may be set up in anticipation of the renewal of equipment. Such a reserve is known as a depreciation reserve. Reserves may be set up for bad debts. In times of recession, this reserve should be larger than in normal times.

If a company is threatened with a civil suit on account of alleged patent infringements, a reserve should be set up immediately in anticipation of this event. If a company is engaged in manufacturing a product, of which the art is very active, that is, many inventions are constantly being made in this field, it may be necessary to set aside a reserve for the purchase of patents or for research to develop new products or improve the present one.

Any number of circumstances, therefore, may demand the establishment of a reserve. Since dividends are payable from surplus only, the real significance of a reserve is to prevent the taking of money out of the business in greater amounts than the future needs of the business in the matter of contingent demands for funds may warrant.

A very important matter in connection with setting up reserves is frequently overlooked, namely, that, when a reserve is set up, it becomes in effect a lien against cash.*

This does not imply that cash on hand must always equal the amount of the reserves plus current needs, but what is required is that the amount and nature of the reserves should have some bearing on the amount of cash on hand. A reserve should always be supported by adequate cash. Just what amount is adequate will depend on the probability of having to meet the situation for which the reserve was created.

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* See Rautenstrauch and Villers, *Budgetary Control*, Chapter XII.

In general, a reserve is set up to protect the total assets, but the ratio which should obtain in any given instance cannot be definitely established.

3. THE EFFICIENCY OF OPERATIONS

Given a certain organization, management may operate it with more or less efficiency, which can be measured directly by the total amount of production and the reduction of cost, or indirectly by (a) turnover ratios, and (b) cost ratios.

a. Turnover Ratios

(1) *The ratio of sales to inventory,* also called *inventory turnover,* is, to some extent, a measure of a company's purchasing and production policies. Inventory, it will be recalled, is made up of raw materials, work in process, and finished goods. The time of converting raw materials into finished products and the availability of raw materials throughout the year are important factors in passing judgment on this ratio. The inventory required by a foundry making gray iron castings from pig iron, which may be purchased any day, is quite different from that required by a manufacturer of industrial alcohol from molasses, which is purchased when the crop is available.

A shirt manufacturer will begin in June the production of shirts which are to be delivered in the fall, and for which he has previously purchased his materials, or at least made his commitments. It may take two months to make an engineer's level, but a loaf of bread is baked in a day. Therefore, the inventory requirements in respect of work in process are quite different in these two industries.

A large inventory of sugar in a rising market is quite different from one in a falling market. Therefore, the inventory turnover must be judged on the basis of the requirements of the business and the characteristic features of both the buying and selling markets in which the business functions.

(2) *The ratio of annual sales to net worth* measures the activity of the money which the stockholders have at the risk of the business. In general, the higher the ratio, the better the investment. The ratio is preferably greater than 200 percent because lower ratios are generally indicative of a hazard to the margin of profit. When the ratio is high it indicates that the business has some slack, that is, there can be a drop in sales without the same consequence to profits as when the ratio is low.

(3) *The ratio of sales to fixed assets* indicates the vitality of the

fixed assets. It also is a measure of a wide or narrow range of sales at a profit. If the ratio is high, it generally indicates that there are low fixed charges on the business, and, therefore, the break-even point is low, with a consequent wide range of sales at a profit. A low ratio, on the other hand, shows a high fixed charge and a narrow range of sales at which a profit can be made. A business with a low ratio is more likely to get into trouble during a period of recession than a business with a high ratio. On the other hand, given two similar businesses, the one with higher fixed assets will, other things being equal, probably have better possibilities of mass production at low cost and, in time of expansion, will be in a better position to earn larger profits. The trend toward *automation* may become a decisive step in this direction.

b. Cost Ratios

The profit and loss statement of a given business may read as in Table VII following.

TABLE VII

STATEMENT OF PROFIT AND LOSS

—— CORPORATION

Month of August, 19—

Sales (net)		$191,957.97	100.0%
Cost of manufacture		160,468.34	83.5
Gross profit		31,489.63	16.5
Administrative and selling expense			
Administrative	$12,226.34		
Selling	6,455.84	18,682.18	9.7
Operating profit		12,807.45	6.8
Other income	1,282.17		
Other expenses	1,237.37		
Net		44.80	
NET PROFIT		$ 12,852.25	6.8+

The percentages show that for every dollar of income received during August, the cost of manufacture absorbed 83.5¢, leaving a gross profit of 16.5¢. The administrative and selling expenses absorbed 9.7¢, leaving an operating profit of 6.8¢. The net of other income and other expense is very small so that the net profit is practically the same as the operating profit. If the cost of manufacture is broken down into its elements, it will appear as follows:

Cost of Manufacture

Labor	$ 60,563.20	31.6%
Materials	42,580.40	22.2
Factory expense	57,324.74	29.7
	$160,468.34	83.5

This analysis shows that for every dollar of income received, 31.6¢ was paid to direct labor,* 22.2¢ was paid for materials, and 29.7¢ for factory expense.*

The important operating ratios derived from the profit and loss statement are accordingly:

(1) Ratio of cost of manufacture to sales
(2) " " labor cost " "
(3) " " material cost " "
(4) " " factory expense " "
(5) " " administrative expense " "
(6) " " selling expense " "

These ratios in any business will vary from month to month with sales for reasons which will be discussed in Chapter XII, which deals with the problem of costs at varying rates of production and sales.

Every engineer knows that no two machines should be treated alike. Some need one sort of care and others require different handling. A steam turbine, for example, must be run with a comparatively high vacuum on the condenser to obtain a maximum economy in steam consumption. A reciprocating steam engine, on the other hand, may not be so materially affected by vacuum conditions as a turbine. A uniflow engine may be operated over a wide range of loads with little change in steam economy, whereas another type of reciprocating engine must run near its rated capacity, since when run at any load above or below its rated capacity a material increase in steam consumption will result. The electrical engineer knows that it is not desirable to use a 10-hp. motor to operate a 2-hp. load, because the current consumption is too great.

Every business has certain characteristics of operation which should be fully understood if they are to be completely controlled. Some of these characteristics are revealed by the operating statement. The above statement shows the following interesting facts about the business to which it relates:

* For the precise definition of these terms, see Chapter X.

(1) The manufacturing division of the business occasions the greatest amount of expense.
(2) The most fertile field in which to attempt to effect economies is in the manufacturing division.
(3) The selling division of the business is not very costly to operate, and, therefore, if all departments of the business are well balanced and the plant is running to capacity, there is not much effort to devote to effecting economies in selling, if expenses have to be reduced for one reason or another.
(4) In general, the margin of profit in this business is largely controlled by efficient factory methods, and therefore this business needs the very best type of factory superintendent.

It is always well to bear in mind that the margin between success and failure is generally very narrow. Any errors in judgment on the part of the sales department in pricing goods, added to errors in judgment in purchasing materials at unfavorable prices, plus errors in judgment in determining methods of processing, in addition to errors in judgment in setting piece rates in the factory, etc., may, through their cumulative effect, completely wipe out an otherwise good margin of profit.

Often the situation is saved through the operation of the law of probability, which provides that all mistakes are not likely to happen at the same time. On the other hand, it is equally true that the law of averages provides that *some* of these mistakes continually occurring prevent a 15 percent profit from becoming a 20 percent profit. It does not always follow that because a business may make a profit of 15 percent, for example, and everybody is satisfied because the business has never been any more profitable, that it could not be made to earn a 20 percent or even a 25 percent profit, if it were managed better. In recent years, a special effort has been made to develop rational methods for measuring the maximum earning capacity of a given business. Among other purposes these methods, which are based upon the use of standard costs, statistical techniques, and mathematical programming, do provide definite standards by which the management of a business may be accurately judged. Actually there is no business, no matter how complicated its operations may seem, which cannot be analyzed and have standards set for its many detailed operations. An approach to the methods to follow will be indicated in Part B of this and in later chapters.

4. THE RESULT OF OPERATIONS

In the final analysis, the value of a business is measured by the amount of profit that is made. Two ratios are of current use: (a) *the ratio of profit (or loss) to the invested capital,* and (b) *the ratio of profit (or loss) to sales.*

The first one was, in the past, almost exclusively and is still today the most currently used. Lately, business groups have been inclined to prefer the second. Much discussion has been going on as to their respective values. From a scientific point of view, they are both useful. The ratio profit (or loss) to the invested capital has the definite advantage of reflecting the turnover of the capital, and, therefore, of giving a better measure of the final result; a o it makes it possible to forecast the probable return of an investment in a given line of business.

Finally, it may be said that the ratio profit-to-sales may be misleading when a comparison is made of results over a span of years.

This year the ratio is 10 percent of sales. Last year it was 15 percent. "What is the matter with us?" the members of the board will say at the January meeting. Neglecting to compare the total sales for this year with the total sales for last year, they ignore that the ratio *cannot* remain constant if the structure of the business is unchanged, and if the total sales do change substantially. The fact is that sales and expenses do *not* vary proportionally, as will be shown in the following chapter, when the ratio total-expenses-to-total-sales is studied. Such a ratio is obviously another form of the ratio profit-to-sales.

In recent years a third ratio has gained increased recognition. It is the *ratio of profit to capital employed.* "Capital employed" is understood to be the sum of all assets employed at any time in the business, equivalent to the left side of the conventional balance sheet. This ratio has been found especially useful as a means of appraising the performance of the decentralized management of a given division in a large corporation. (See, among others: Harvey O. Edson, "Return on Investment as a Measurement of Management Efficiency," *The Controller,* June, 1957; also G. Moller in *The Controller,* November, 1957.)

Referring to the above ratios, in general, it may be stated that it is always helpful to compare similar ratios for a series of balance sheets to determine the tendencies of the business, for, although a given set of ratios may seem favorable for a given balance sheet, if they are *tending* in a wrong direction, there is something wrong with the business which demands correction.

It is helpful to realize that an analysis of the above nature is gen-

erally made by the banker whenever a company is negotiating for a loan, particularly if the bank has not had much experience with the borrower. Accordingly, it is helpful if the borrower makes such an analysis himself and supplies such explanations as the results of the analysis may warrant before making applications for the loan.

When the invested capital consists of bonds, preferred stocks, and common stocks, a further analysis is usually made with respect to each class of security. Such ratios are:

a. Earnings divided by bond interest. Since bonds have a prior lien on earnings, the margin of safety of the bonds may be expressed in terms of the ratio of the amount of bond interest to the amount of earnings.

b. Earnings minus bond interest payable, divided by the preferred dividends payable, measures the amount of times the dividend on the preferred stocks have been earned.

c. The earnings on the common stock are usually determined by dividing the earnings, after payments of bond interest and preferred stock dividends, by the number of shares of common stock outstanding.

APPENDIX

FEDERAL TRADE COMMISSION REPORTS ON FINANCIAL RATIOS

As discussed above, it is very important for the manager of any business enterprise who intends to use financial ratios to know the acceptable values which each ratio under consideration should have for the particular business he is managing and the particular period he is concerned with.

There is no rigid solution to this problem. Each business differs from every other business as each individual differs from every other individual. For this reason, the financial ratios obtained in another business cannot be considered as a valid standard of measurement. They are, however, likely to throw some light on a given situation if the conditions of operation of the business under consideration are not too fundamentally different from those prevailing in the business or businesses with which the comparison is being made.

In fact such comparisons are current practice in industry and in banking circles. This raises, of course, the question of selecting the business or the group of businesses with which the comparison is to be made and of obtaining the necessary information.

In making the selection, many considerations should be given attention, especially the size of the enterprise, the kind of industry it belongs to and the conditions of operations.

To obtain the necessary information is becoming easier than it was some years ago, because businesses tend to be less restrictive than they were in the past in disclosing their financial data. In addition, trade associations, as a rule, make available to their members a great amount of financial information collected from other members who remain anonymous. Special studies such as the one presented above in Table VI and studies periodically published in leading magazines are also available.

Another and very useful source of information that should be kept in mind are the *Quarterly Financial Reports for Manufacturing Corporations* issued jointly by the Federal Trade Commission and the Securities and Exchange Commission.

Because they are based upon the grouping of a great number of individual enterprises and upon carefully developed sampling techniques the data published in these reports can be considered as reliable averages.*

Because some of the grouping is based upon the size and some of the grouping based upon the kind of industry considered, the ratios provided can, to a certain extent, be selected in accordance with the conditions of operations of the business under consideration.

TABLE VIII

FINANCIAL RATIOS

FOR MANUFACTURING CORPORATIONS

(by assets size)

Assets Class	Profit before Federal Income Taxes per dollar of Sales	Profit before Federal Income Taxes per dollar of Stockholders' Equity	Cash plus Government Securities to Current Liabilities
All assets sizes	9.7	24.6	.69
Under $250,000	1.3	6.5	.37
$250–999,999	3.1	12.2	.47
$1M–4M999	5.5	17.9	.53
$5M–9M999	8.4	21.5	.65
$10M–49M999	10.1	23.7	.67
$50M–99M999	10.0	24.0	.69
Over $100M	12.8	28.1	.77

* For a discussion of the sampling methods, see Report for 2nd Quarter, 1952, pp. 26*ff*., and Report for 3rd Quarter, 1953, pp. 20*ff*.

TABLE IX

FINANCIAL RATIOS
FOR MANUFACTURING CORPORATIONS
(by industry)

	All Manufacturing Industries	Durable Goods	Non-durable Goods	Machinery	Motor Vehicles	Food	Tex. Mills	Paper
Sales	100	100	100	100	100	100	100	100
Cost & Expenses	90.3	88.9	91.8	89.6	85.8	95.7	94.5	88.0
Net profit from operations	9.7	11.1	8.2	10.4	14.2	4.3	5.5	12.0
Other income or deductions (net)	.6	.3	.9	.4	.6	.1	.1	.1
Net profit before Fed. Inc. Taxes	10.3	11.4	9.1	10.8	14.7	4.4	5.6	12.2
Net profit after taxes	5.6	5.8	5.5	5.3	7.0	2.2	2.8	6.2
Annual rate of profit on stockholders' equity before Fed. Inc. Taxes	24.6	28.5	20.8	22.8	45.8	16.9	13.1	24.1
After taxes	13.5	14.4	12.6	11.2	21.7	8.4	6.5	12.3
Current Assets to Current Liabilities	2.41	2.24	2.66	2.80	1.72	2.47	2.73	2.65
Total cash and U.S. Gov. securities to total current liabilities	.69	.67	.71	.63	.77	.54	.49	1.04

Because the reports are quarterly, they make it possible to take into account the seasonal variation factor, which is important in most businesses whether or not they are considered as a "seasonal business."

Some of the significant ratios thus published jointly by the F.T.C. and the S.E.C. are presented in Tables VIII and IX. They relate to the fourth quarter 1955.

B. PREDETERMINED STANDARDS

Such standards may be either based wholly on the results of past performances of the business or established on a more scientific basis for estimates.

1. Past Performances

When the balance sheet of a company as of a given date is compared with its balance sheet as of another date, many changes in values of the items will be found. A company's statements of assets and liabilities as of 1957 and 1956 will show value changes which took place during 1957. If the net worth has increased during the year, that is, the net worth before dividend disbursements from surplus, the business has been conducted at a profit; and if it has decreased, the business has been unprofitable.

The comparative balance sheet statement for the months of July and August, 19–, of the company to which the profit and loss statement in Table VII relates is given in Table X.

This statement shows what has happened to the values of both assets items and liabilities items during the month. The change noted in the surplus ($12,852.25) shows the profit realized during August operations. The disposition of the profits, that is, what was done with the profits, is shown in the other changes. The net change in assets was an increase of $3,208.59, and the net change in liabilities was —$9,643.66.

The profit or loss made during any time period might therefore be learned by comparing the balance sheets at the beginning and end of the period. But this comparison does not enlighten us on the causes of profits or losses. This must be learned from the profit and loss statement directly.

A similar comparison may be made between two balance sheets of successive years. Taking into account the factors that, independent of management's action, may have influenced the conduct of the business (such as changes in general economic conditions, higher wages,

TABLE X

COMPARATIVE BALANCE SHEETS

——— Corporation

Comparative Balance Sheet as at
August 31, 19– and July 31, 19–

Assets	*August 31*	*July 31*	*Increase or Decrease*
Current			
Cash	$ 148,968.48	$ 132,940.27	$ 16,028.21
Accounts receivable	217,930.47	217,585.99	344.48
Inventory	288,888.62	303,012.51	−14,123.89
Fixed			
Properties less depreciation	1,314,378.26	1,312,338.29	2,039.97
Other			
Deferred items	35,186.24	36,266.42	−1,080.18
Patents, etc.	949,880.04	949,880.04	——
TOTAL	2,955,232.11	2,952,023.52	3,208.59
Liabilities			
Accounts payable	38,275.89	44,605.90	−6,330.01
Accrued liabilities	16,830.41	20,691.33	−3,860.92
Other	68,891.44	68,344.17	547.27
Total	123,997.74	133,641.40	−9,643.66
Capital and Surplus			
Capital stock	1,500,000.00	1,500,000.00	——
Surplus	1,331,234.37	1,318,382.12	12,852.25
TOTAL	2,955,232.11	2,952,023.52	3,208.59

etc.), it will be possible, to a certain extent, to use the previous balance sheet as a yardstick to measure the actual performance.

This, however, assumes that the previous balance is an adequate yardstick, which is not established.

2. *Estimated Standards—Variance Analysis*

A better approach is to provide such a yardstick established on a scientific basis. It is not the purpose of this study to enter into the details of the technique used, which are the subject of cost accounting. Only the general principles involved will be indicated.

The first step is to determine the standard direct expenses. There are two ways of establishing them. One is to rely on past experiences. But such a method does not provide results fundamentally different from a comparison with the financial statements of previous years.

The other method is to compute the expenses on the basis of scientific studies. The expenses for labor, materials, power and other items

incurred for a given rate of production as well as other expenses of operation may be estimated quite accurately by well-known engineering techniques.* From these estimates the cost of goods sold for any rate of production may be readily determined. By this means a scientifically determined standard is provided for comparison with actual performance. Such standards must, of course, be revised from time to time to take into account the changes in the values of the economic factors, such as wages and prices on which they are based.

The second step is to compare the actual data to the standards and, when warranted, to provide an analysis of the difference between the two—this is called the *variance analysis.*

The performance of an enterprise may also be measured from the standpoint of the investments and services required to keep a productive (direct-labor) employee at work and by the value of salable goods he produces in a given time. Some years ago one of the writers devised and used a unit of measurement relating to the above facts which has been found of some service in comparing the performance of a given industry from time to time, and in comparing one industry with another. This method is suggested by the following observations:

A workman in a given factory receives a certain total wage per year. The company produces a quantity of goods which it sells for a certain sum of money. A known quantity of material is consumed in manufacturing the goods. A certain amount of service is rendered to tl , direct-labor employees during the given year at a given cost. The total plant investment is known. The company employs a certain number of productive or direct-labor employees. The goods produced vary with the number of direct-labor employees at work. In another company all the quantities are different. Therefore, one company will differ from another in the value of goods produced per productive (direct-labor) employee, as well as in the capital invested to permit his being employed.

The question now arises: What is a satisfactory unit of measurement, and what are the significant factors to be measured? Will the number of direct laborers employed during the year be a satisfactory unit? No, because not all the direct laborers have been employed all the time during the year. Will the average number do? No, because the average number does not mean anything. Apparently, we must devise a unit which is representative of a man being continuously

* For a presentation of the use of sampling techniques developed for the purpose of determining standards in the case of non-repetitive work, see Ralph M. Barnes, *Work Sampling,* John Wiley and Sons, Inc., 1957.

employed throughout the year at direct labor. Such a unit (effective direct-labor employee) is the number of direct-labor-hours paid for during the period divided by the number of hours the shop was operating during the period. Since statements of account are balanced monthly and annually in most businesses, these numbers may be conveniently used to represent the monthly and annual status of the business in terms of the unit productive man (effective direct-labor employee). Every manufacturing enterprise of any consequence keeps a record of direct-labor-hours available on a weekly basis, so this unit of measurement can be easily applied. If, for example, the number of productive labor hours paid for in a given industry is 224,000 for a certain month (and the factory operated for 175 hours during the month), it may be stated that 1,280 unit men were employed during the month. The payroll may show 1,540 direct-labor employees at work during the month, but an examination of each name may show that 40 of them worked only 2 weeks, 50 for 10 days, and a number were out part time because of illness and other causes.

Monthly comparisons are useful in measuring conditions in any particular business. Because of seasonal variations the annual basis is the better for comparing one business with another. The conditions to be measured will vary with different enterprises because some factors are more important in one business than in another. In general, however, the following relationships are useful:

1. Wages per unit man per month
2. Materials cost per unit man per month
3. Factory expense per unit man per month
4. Administrative expense per unit man per month
5. Selling expense per unit man per month
6. Sales value produced per unit man per month
7. Profit per unit man per month
8. Number of service employees per unit man per month
9. Fixed capital per unit man per month
10. Working capital per unit man per month
11. Inventory value per unit man per month.

Suppose these ratios are found. What good are they? What can be done about it? The answer is—nothing, unless it is also known *what these ratios should be*, and what is to be done to bring them up to standard. All measurements are comparative. If there is no standard of comparison there can be no measurement and therefore no managerial control in the true sense of that term. Performance and the

state of things may be compared with other performances and states of things, and we find that one is more or less than the other. But how much do they vary from what they should be? That is the question. The "what should be" is the standard.

A salesman once sought the approval of one of the writers because he had increased sales 100 percent in a territory in which he had recently been installed. By his standards (past records) he did well. His standards, however, were wrong, for the territory had a much greater potentiality—he should have done three times the amount of business he did. His standards were too low.

As a general rule it is very difficult to determine at the outset the maximum standard of accomplishment and the minimum costs required in each department of a business over a given period of time.

Attempts to measure performance in terms of the unit productive man are best made on the basis of present conditions and, by a continued study of operating conditions, gradually to bring about improvement and strive for higher standards. But it is essential, if a business is to be brought up to its highest state of efficiency, to have standards of accomplishment which are possible of attainment. Let us take a current operating report and put it in a form to show the characteristics of the business on the basis of the unit productive man.

A given business, manufacturing and marketing a machine shop product, shows the following performance for the month (round numbers used):

TABLE XI

MONTHLY STATEMENT

—— Inc.

Sales		$187,500
Labor	$ 15,625	
Material	100,000	
Factory expense	25,000	
Total cost of sales		140,625
Gross profit		46,875
Administrative expense	2,250	
Selling expense	10,000	
Total general expense		12,250
Operating profit		34,625

Operating records show that there were:

1. 21,875 direct-labor-hours
2. 15,000 indirect-labor-hours
3. 200 shop hours.

Let a unit productive man be represented by 200 direct-labor-hours. Accordingly, the 21,875 direct-labor-hours will represent the equivalent of 110 men continuously employed during the month at direct labor. This record shows that, for every man (unit man) employed during the month, goods to the value of $1,745 were produced and sold, and that it cost to maintain this man:

Wages for labor	$ 142.00
Materials for product	910.00
Factory expense	227.00
Administrative expense	20.00
Selling expense	91.00
TOTAL	$1,390.00

For every dollar paid the man in wages, the company supplied him with $6.40 of material to work upon and furnished him with services to the amount of $2.38.

The indirect labor record shows that every group of approximately four men employed at direct labor had three men to serve them in various capacities. The balance sheet of the company shows an investment in fixed assets of $500,000. Therefore, the company invested $4,545 for each man employed at direct labor. The company makes a profit of $315 per month on each productive man.

A certain manufacturer of electrical instruments maintained the following average monthly record during a certain year:

Monthly Performance per Unit Man:

Sales	$1,200
Wages for labor	112
Materials for product	342
Factory expense	274
Administrative expense	65
Selling expense	252
Profit	155

Every group of five operators employed at direct labor had seven operators to serve them. The company had $4,160 invested in plant for each direct-labor employee, and the working capital invested was $5,050.

The value of such an analysis is based on the proposition that the quantity of goods produced and sold during a given period of time by any company will depend upon the number of men employed at

direct labor engaged in producing the goods. The profits will depend on how much it costs to keep the man at work both in wages paid and services rendered to help him do the work and to get the orders for him to work on.

Each division of a business may be analyzed in the same manner as the business as a whole, and each division manager will then have a method of measurement to guide him. The value of ratios such as the above in comparing one industry with another is at once apparent. Modifications and subdivisions of the above ratios, as required for any particular business, will immediately suggest themselves when a study of that business is undertaken. The important problem is finding the principal indications of business trend and establishing simple, convenient methods of getting the facts about them.

IV

SALES-EXPENSE RELATIONSHIPS

REPORTS on the state of the assets and liabilities of a business at any particular time (the balance sheet), and reports of the use of funds in manufacture and trade over a given time period, with resulting profit or loss (the profit and loss statement), while important documents, are nevertheless not wholly sufficient as guides to managerial policy. Some new dimension must be provided to give the necessary perspective. Such is the aim of the profit and loss chart, the break-even chart, and the sales mixture chart. These charts actually complement each other, and it is often advantageous to use them simultaneously. In recent years, the author has attempted to effect a sort of synthesis of these three charts by the method of *differential profit control* which will be presented in this chapter.

I. THE PROFIT AND LOSS CHART

Attempts to provide perspective to the course of business usually follow the pattern of graphic portrayal of tabular statements of profit

and loss for a period of years and the secular trend—such as charts showing the variation of important items of the financial statements with time. Thus, the charting of trends of sales with time, expenses with time, and profits with time, etc., are intended to establish the course a business takes with respect of these particulars.

Another method used is to set up a tabular statement, showing the ratios of certain items of the profit and loss statements, such as cost of manufacture, cost of materials, and cost of labor to sales, month by month or year by year. To illustrate, let us examine the comparative statement for the beverage industry for 74 manufacturers in the $250,000–$1,000,000 assets group for 1941 to 1945 (Federal Trade Commission: "Wartime Costs and Profits for Manufacturing Corporations," October 6, 1947, Appendix, Table XII).

TABLE XII

COMPARATIVE FINANCIAL STATEMENTS, 1941–1945, FOR THE BEVERAGE INDUSTRY FOR 74 IDENTICAL MANUFACTURERS IN THE $250,000–$1,000,000 ASSETS GROUP

Comparative Profit and Loss Statement

Item	1945	1944	1943	1942	1941
	(Thousands of Dollars)				
1. Net sales	$130,440	$123,905	$102,113	$74,868	$63,392
2. Materials used	41,383	41,463	31,332	19,962	15,622
3. Labor	9,697	9,262	7,766	5,670	4,738
4. Other manufacturing cost	50,602	46,588	37,617	29,459	25,819
5. Net change in inventories	+157	−798	−73	−297	−221
6. Cost of goods sold	101,839	96,515	76,642	54,794	45,958
7. Gross profit on sales	28,601	27,390	25,471	20,074	17,434
8. Selling, general, and administrative expenses	18,308	16,348	15,008	14,175	14,011
9. Net operating profit	10,293	11,042	10,463	5,899	3,423
10. Non-operating income	523	515	438	411	331
11. Interest and expenses on long-term debt	44	54	57	94	113
12. Other deductions except long-term debt interest	396	545	866	471	441
13. Net income before taxes and special reserves	10,376	10,958	9,978	5,745	3,200
14. Income and excess-profits taxes	6,588	6,943	5,811	2,876	1,227
15. *Net income after taxes and before special reserves*	3,788	4,015	4,167	2,869	1,973
16. Cash dividends	1,711	1,779	1,657	1,301	1,051
17. Depreciation, depletion, and amortization	1,849	1,858	1,936	1,903	1,838
18. Management salaries	2,238	1,975	1,910	1,711	1,556

As we examine this statement we find that these data do not indicate much more than the fact that such items as net sales, expenses, and profits, have increased during these years, and net increases after taxes and before special reserves increased from 1941 to 1943 and declined in 1944 and 1945. If we plot certain of these items by years, such as net sales, cost of goods sold, materials and labor, we obtain the chart of secular trend as shown in Figure 8. The series of four lines shown on the chart indicates irregular behaviors in time. If we tabulate certain ratios of expenses to sales, we get the data of Table XIII.

TABLE XIII

THE BEVERAGE INDUSTRY
$250,000–$1,000,000 Assets Group
Ratios of Expenses to Sales

	1941	1942	1943	1944	1945
Cost of Goods Sold / Sales	72.5%	73.3%	75.0%	78.0%	78.5%
Materials / Sales	21.4%	26.7%	30.7%	33.4%	31.6%
Labor / Sales	7.47%	7.6%	7.6%	7.46%	7.46%

These ratios indicate that the ratio of cost of goods to net sales has increased from 1941 to 1945; that of materials to sales also increased from 1941 to 1944 but declined in 1945 from 1944; and that of labor to sales was fairly constant. But these tabular statements, together with the chart (Figure 8) do not indicate *why* the variations of expense to sales have occurred. They do not establish any basis for forecasting such variations nor for estimating the probabilities of the amount of such expenses with a given net sales. They are therefore mainly historical documents of limited use in anticipating the financial needs of the business as sales increase or decline or for exercising managerial control.

Is there any way in which these data may be made to reveal the information needed by the businessman, for forecasting the financial requirements of the business as to the different classes of expenses to be incurred as sales either increase or decline or for exercising managerial control? If there is such a way, it must be by establishing some functional basis for relating the data of the profit and loss statements.

Figure 8 suggests that as sales increase with the years, the expenses increase also. It also indicates some similarity in the *forms* of the secular trends in expenses and the *form* of the secular trend in sales. This seems reasonable since experience teaches us that expenses and sales go hand in hand. This suggests that there must be some func-

tional or dependent relationship between expenses and sales. Is there any regularity in this dependence? If so, it appears to be functional; a direct cause and effect relationship. Let us try this suggestion by plotting expenses in relation to sales.

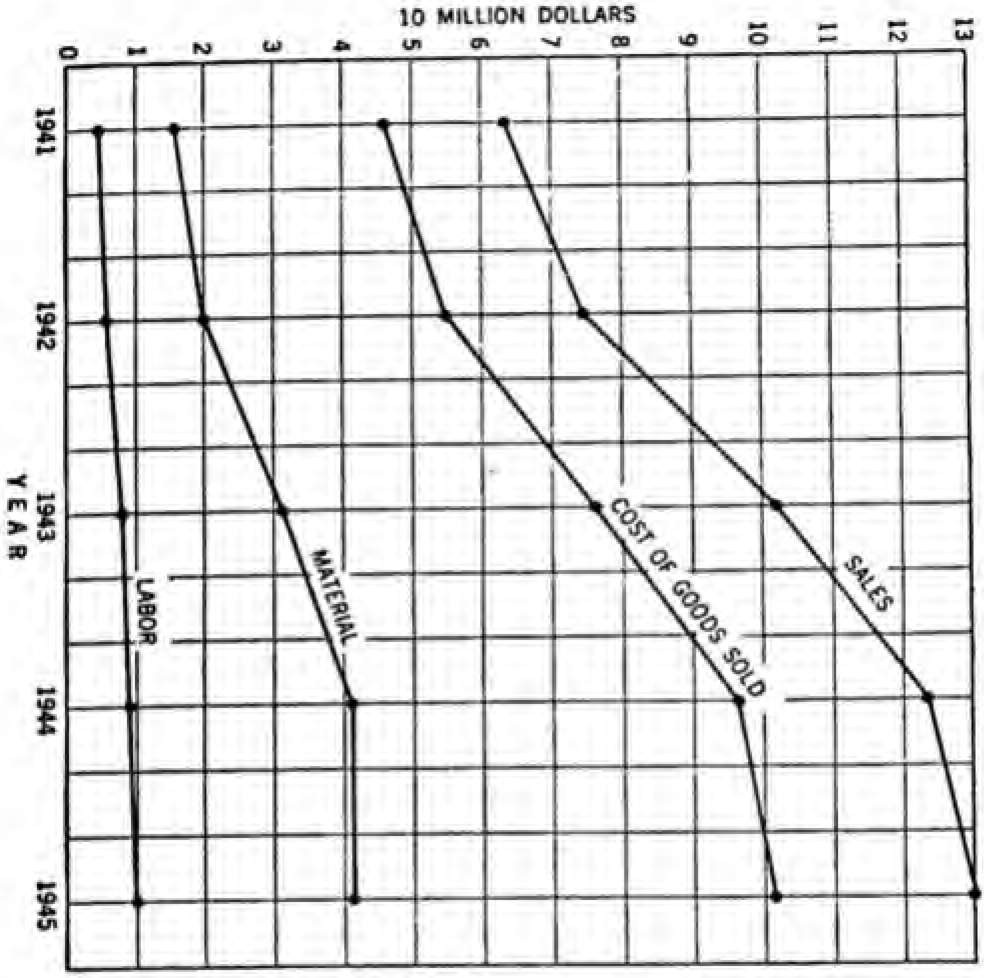

Figure 8. Beverage Industry Secular Trends, 1941–1945 ($250,000–$1,000,000 Assets Group)

Let us plot three items of expense in this manner. This is done in Figure 9 and, interestingly enough, it is found that these expenses are very definitely and specifically related to sales. In fact, each of these items of expense, when plotted against sales, falls along a straight line of central tendency. When, therefore, the relations of expenses to sales are examined functionally instead of in time perspective, a new meaning is given to them. This new meaning not only informs us as to "how" but also as to "the reasons for how much." The "reasons for how much" is the new dimension which is given the data

of the profit and loss statements.* Not only does the chart Figure 9 reveal a consistent trend for each item of expense in relation to sales but it also enables us to determine these relationships *quantitatively*. This may be done as follows.

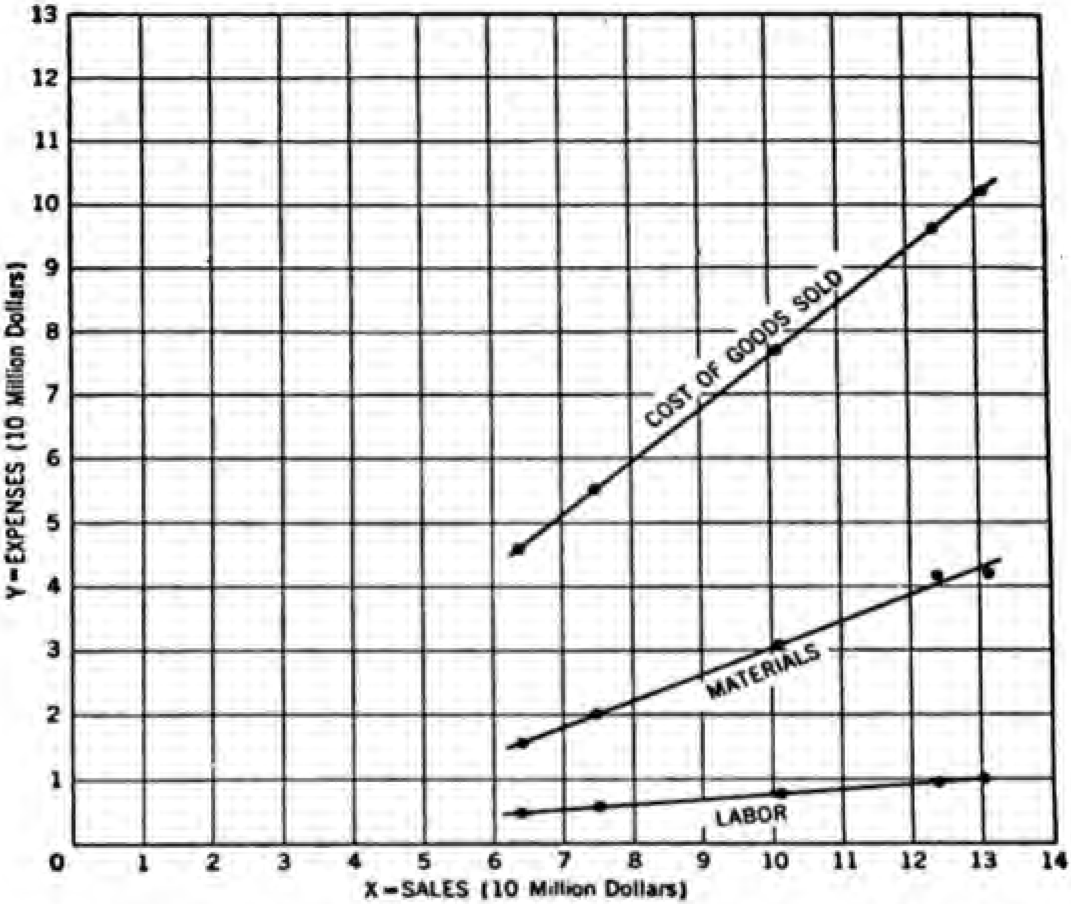

Figure 9. Beverage Industry Expenses *vs.* Sales, 1941–1945 ($250,000–$1,000,000 Assets Group)

In the case of the trend line of the cost of goods sold it is found from the chart that when Sales $x = 65$ millions, the Cost of goods sold $y = 47$ millions, and when Sales $x = 130$ millions, then Cost $y = 101$ millions. Thus the rise of the trend line is $101 - 47 = 54$ millions for an increase in sales of $130 - 65 = 65$ millions. The slope of the trend line is therefore $\frac{54}{65} = 0.83$ or 83 percent. Where would the trend line cross the Y-axis if it were extended? This may be found by noting that if the trend line should pass through the origin, the

* This method of analysis, resulting in the Profit and Loss Chart and the Break-even Chart, was devised by Rautenstrauch more than 40 years ago.

cost for Sales x of 100 millions should then be 83 percent of x or 83 millions. But the chart shows that the cost for sales of 100 millions is actually 76 millions. This, of course, could only occur when the trend line cuts the Y-axis at a point $83 - 76 = 7$ millions *below* the origin.

If then -7 be designated by k and 0.83 be designated by v, the general equation of trend of expense (e) in relation to Sales x becomes

$$e = k + vx$$

Thus, if the trends of costs or expenses in relation to sales as shown in Figure 9 are computed, it is found that the average tendency of cost or expense to vary with sales in each of these cases is:

Cost of goods sold $e_1 = -7$ million dollars + 83% of sales
Materials $e_2 = -11.5$ million dollars + 42% of sales
Labor $e_3 = 7.5\%$ of sales

The use of equations of trend for all items of cost or expense in forecasting the financial needs of a specific business, as sales are anticipated to rise or fall, will be developed later. At the present time, we must answer the question: Is this a special case? Before placing too much reliance on this method of analysis as a guide for the future, we must assure ourselves that this is not an isolated instance.

Let us, therefore, take a large representative company such as the United States Steel Corporation and examine its profit and loss statements.

The United States Steel Corporation reports the results of its operations from 1902 to date in its annual reports from which are selected the following data of three different periods: the early period from 1902 to 1910, the middle period from 1920 to 1929, and the later period from 1943 to 1955. These periods were selected at random instead of the continuous record to simplify the presentation as to size of chart.

The sales (products and services) and the expenses (before taxes and interest on debt) for each of these periods are as in Table XIV. These data are plotted in Figures 10, 11, and 12. We find the trends of expenses (before interest and taxes) in relation to sales.

From 1902–1910, the trend is: Expenses = \$60M + 60% Sales
From 1920–1929, the trend is: Expenses = \$33M + 80% Sales
From 1943–1955, the trend is: Expenses = \$335M + 74% Sales.

In this example, we find three distinct trends of expenses (before interest and taxes) with sales for the periods selected for illustration.

TABLE XIV

UNITED STATES STEEL CORPORATION

Year	Sales	Expenses (Before Interest and Taxes)
	(Millions of Dollars)	
1902	423.1	309.1
3	398.2	314.2
4	324.9	261.5
5	409.2	307.2
6	484.0	352.1
7	504.4	363.0
8	331.6	249.2
9	441.1	321.9
10	491.8	364.9
1920	1290.6	1075.4
21	726.0	623.2
22	809.0	705.2
23	1096.5	904.7
24	921.4	763.7
25	1022.0	853.4
26	1082.3	886.4
27	960.5	800.2
28	1005.3	811.5
29	1097.4	830.0
1943	1972.3	1777.5
44	2082.2	1910.6
45	1747.3	1619.0
46	1485.7	1347.7
47	2116.6	1902.7
48	2473.7	2242.3
49	2293.9	2010.6
50	2947.4	2502.3
51	3509.7	2932.4
52	3131.7	2875.0
53	3853.0	3304.5
54	3950.4	2859.7
55	4099.7	3359.6

We also find that each trend is straight but different in amount from the others.

Finally, we see that if an additional technique is applied to this type of chart, it will be possible to visualize the historical trend of *profits* with sales over a span of several years. Thus trends in gross profits, operating profits or net profits, with variations in sales during different

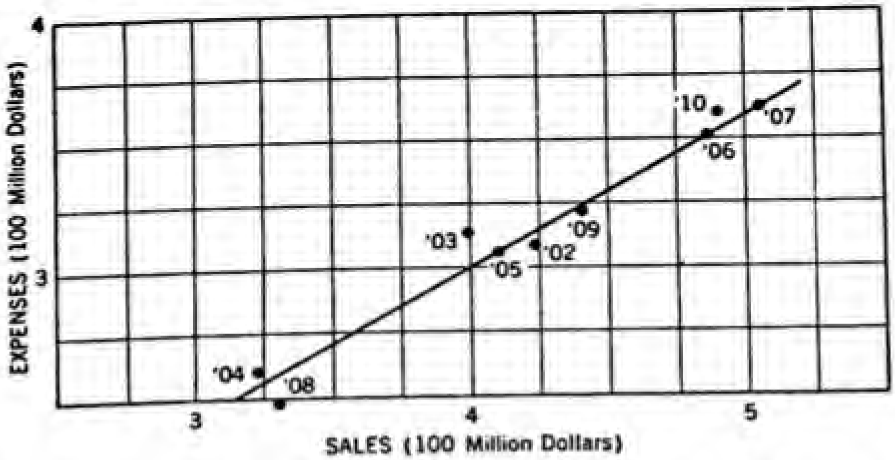

Figure 10. United States Steel Corporation Sales *vs.* Expenses before Interest and Taxes, 1902–1910

time periods or spans of years, may be visualized. This technique is demonstrated in Figure 13 through the use of the trend line developed in Figure 11.

In Figure 13, the expense points and their trend line, as shown in Figure 11, are reproduced. If now a vertical be drawn through a given expense point, such as for 1921, when sales were 726 million dollars,

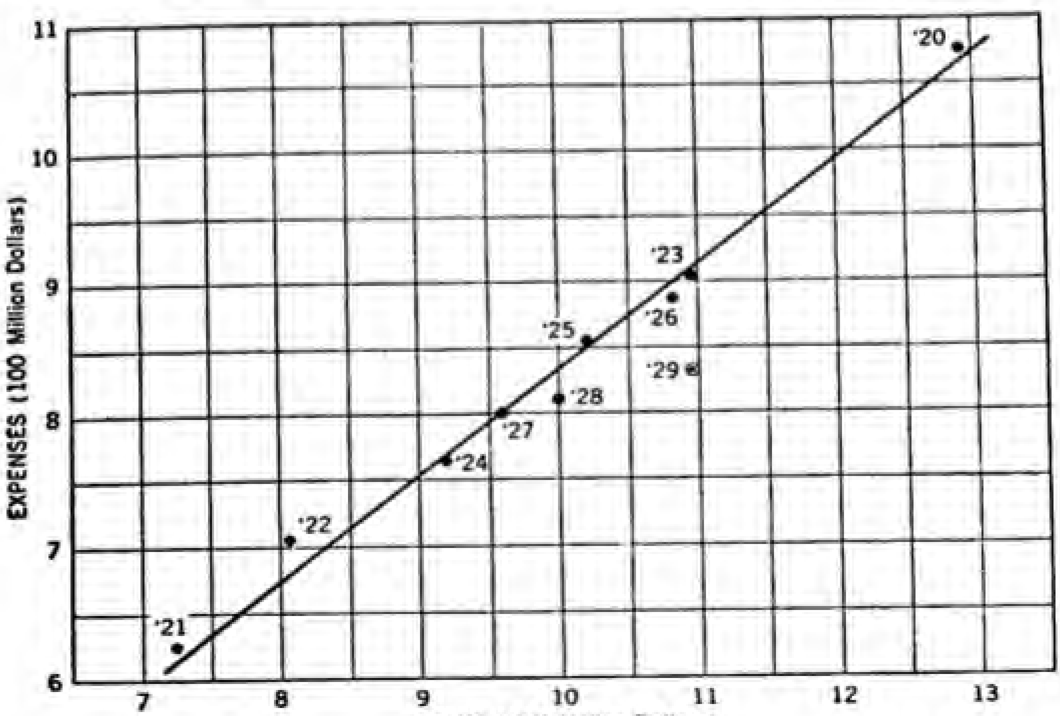

Figure 11. United States Steel Corporation Sales *vs.* Expenses before Interest and Taxes, 1920–1929

and the length of this vertical be terminated at A (726 million dollars), it follows that the distance from the expense point to A will equal Sales-expenses = Profit. If again, for the year 1920, for example, a vertical is drawn through the expense point (1,075.4 million dollars) and this vertical is terminated at a point B, which reads 1,290.6 mil-

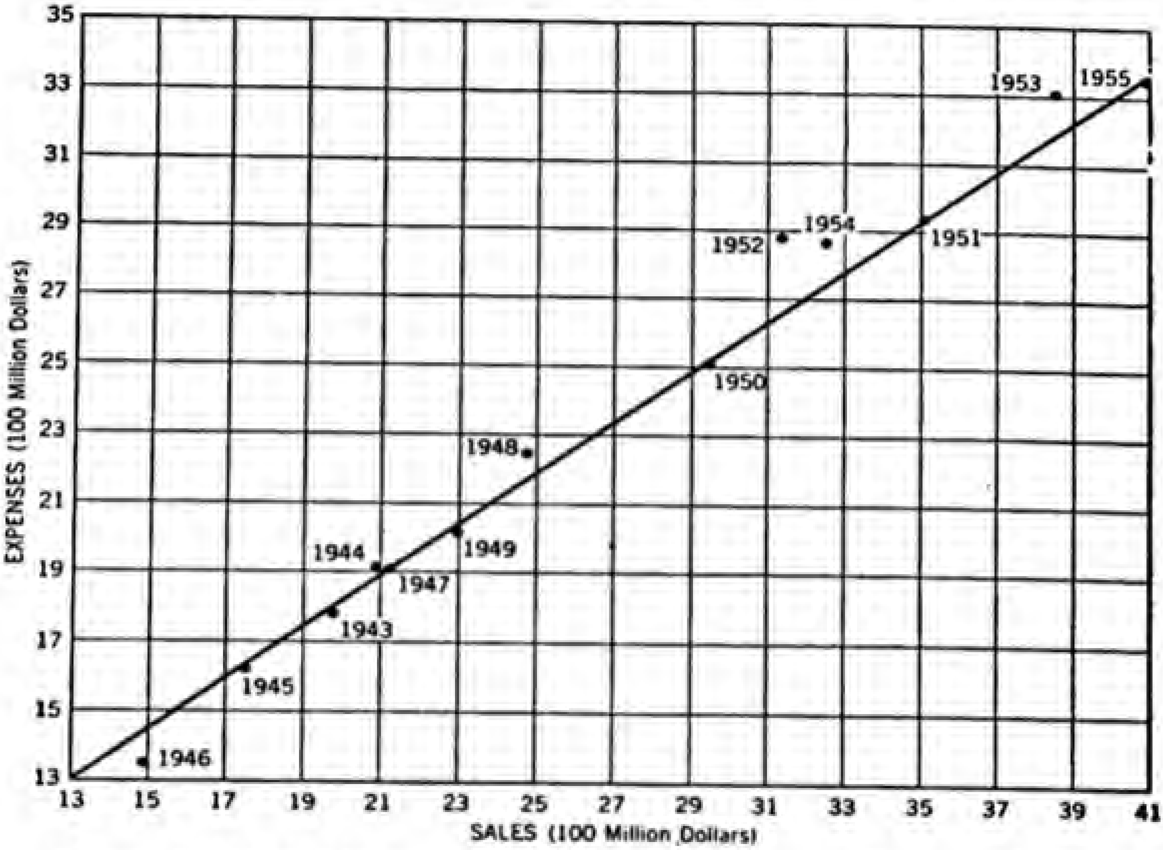

Figure 12. United States Steel Corporation Sales *vs.* Expenses before Interest and Taxes, 1943–1955

lions of dollars (sales) in the vertical scale, it will appear that the distance from B to the expense point will equal the profit for that year. If A and B are joined, it will be observed that the line thus generated will lie at an angle of 45° with the X-axis or the Y-axis, provided the same scales are used for the X- and Y-axes, and would, if extended, terminate at the origin of the axes. This additional technique permits the chart to reveal profit or loss as well as expenses and sales. Not only does it record the actual profit or loss for any given year but it also shows the variation of any particular profit or loss from the general trend, whence the name *Profit and Loss Chart*. Figure 13 is the Profit and Loss Chart for the United States Steel Corporation for the years 1920 to 1929.

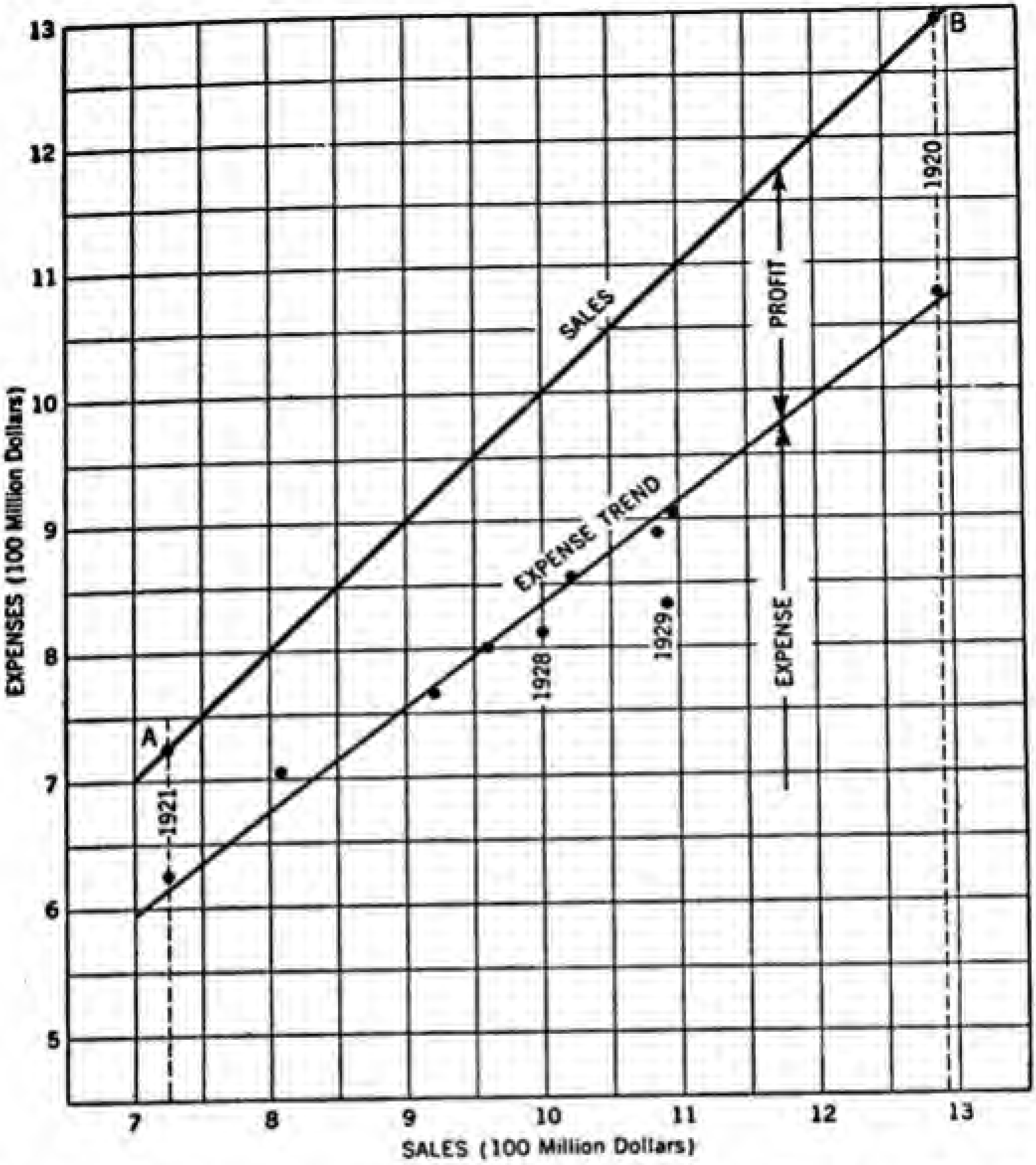

Figure 13. United States Steel Corporation Expense Trend, 1920–1929

What general conclusions may be drawn from what has been observed so far about the relations between sales and expenses?

In the first place, the regularity of the sales and expense relationships so far observed suggests that expense is functionally related to sales. This appears to be the case for a whole industry as well as for an important unit in an industry chosen at random, from hundreds of industries and companies.

In Chapter V are shown the profit and loss charts of many well-known companies, all of which conform to the above pattern of relation between sales and expenses. Some companies experience new

trends from time to time due to changes in the financial structure and methods of production as the business of the company expands. But the straight-line trends of the expenses either at higher or lower levels appear to persist for a span of years.

Why do the expenses show a straight-line relation to sales? Why should there be several trends, for any company, over a period of years?

In the first place, it should be noted that what have been plotted above are the *relations between expenses and sales,* and, just as expenses are influenced by the costs of materials, labor, and fixed charge, so also is the dollar value of sales influenced by the selling price of the quantities sold. Since, as a general rule, costs are reflected in prices, that is, prices are adjusted to costs (except under government controls as formerly experienced in some instances), such adjustments appear to control also the trends of expenses to sales and hence maintain a consistency of pattern over a span of years.

In the second place, it should be noted that a company may be the same legal entity for a span of years, but at the same time it may, and usually does, experience changes in both its financial and physical structures. The United States Steel Corporation today is by no means anything like what it was in 1902, in physical equipment, financial structure, personnel, or in many other particulars. Also, the economic environment in which it operates, as characterized by wages and prices, is changing with time. The financial structures of companies, with their consequent effects on fixed charges, also change in time. Accordingly, with such changes, the expenses of operations per unit of output will stand at different levels over a period of time. When the United States Steel Corporation, for example, replaced its hand sheet mills with cold rolled continuous mills, the labor cost per ton of output declined, since fewer men were needed for the same output.

But the important matter to note is that this type of analysis reflects the economic consequences of all these changes over a long span of years. The profit and loss statements for these years can not of themselves give any such perspective of the trends of expense with sales.

In the third place, the items of expense have different relationships in respect of sales, which relationships must be clearly defined if the general pattern of the relation between sales and expenses is to be dealt with intelligently.

It is necessary to inquire into such relationships *at a given time* in order to eliminate the effect of changes in environment and in the company's economic structure. If there is a functional relationship

between sales and expenses over a span of years—and we have now seen that there is one—then, logically, there should also be such a relationship when the period considered becomes shorter than a year, say a month or a week.

II. THE BREAK-EVEN CHART

Let us now, therefore, inquire into the sales-expenses relationship at a given time. The first step in this analysis is to examine the expenses of operating a business, including manufacture, with respect of their functional relation to sales.

A. CLASSES OF EXPENSES

An analysis of the origin and nature of the items which make up the total expenses of a business at any particular time reveals that these items fall into two main groups, which are either *constant* (fixed plus regulated) or *variable* with respect of sales or output.

1. The *constant expenses* arise from three sources:
   a. Those occasioned by the possession of a business
   b. Those assessed for purposes of capital recovery of investment in fixed assets
   c. Those which arise in its operation.

The *costs to possess* are interest on mortgages, local taxes, insurance, and rent. These items of expense are based on the values of the assets possessed, and the rates of interest, insurance, and taxes applied to these values. The *costs of capital recovery* are determined by accounting for depreciation by methods to be considered in Part II. The costs to possess and the charges for capital recovery (depreciation) together are frequently referred to as the fixed charges and are usually expressed on an annual basis. In financial circles, the term "fixed charges" refers to charges against bond and other investment certificates.

Thus, if the fixed assets of a business are $10,000,000 and the rates of insurance, taxes, and depreciation total 12 percent, and if there is a mortgage of $3,000,000 on the property bearing 5 percent interest, the annual fixed charges are $1,350,000 and are due and payable * whether the factory is closed or is running to full capacity.

Another group of total constant expenses arises from the operations of the business at any particular time. These expenses are determined

* Depreciation is not currently payable but is incurred as an amortization of a prepaid item.

in part by the organic features of the business and also *in part* by executive policy concerning appropriations for such operations. For instance, the annual expenses of heating, lighting, part of power (connected load charge in the case of purchased power) and a portion of maintenance and repair of buildings and machinery are, for *any particular year*, in the life of a business fairly constant, and specific amounts of money may be budgeted annually for meeting such expenses. These expenses, moreover, are within limits controllable by management, since the amount of such expenses depends in part on how such services are organized and managed. These expenses are, to a degree, regulated from time to time by the executives of the business but for any year are budgeted as specific amounts, and are therefore considered as constant over a wide range of sales.

Another group of expenses, which is set up on an annual basis as a company anticipates its expenses for an approaching year or accounting period, consists of executive salaries and appropriations for advertising and other operating expenses which experience has shown are fairly constant, as sales vary over an appreciable range. A going concern at any particular time maintains a number of employees who are on annual salaries. The officers of the company, the department heads, and minor officials are in this class. The salaries of these employees are determined and regulated from time to time by executive action. But *for any particular year*, the total of such annual salaries is a determinable amount. If, later, the volume of business expands and the company prospers, salaries of officers may be raised and new salaried employees may be engaged. With a serious decline in sales, the number of salaried employees may be materially reduced. But at any time, the company's books will show a list of salaried employees together with their monthly or annual salaries and the total of such salaries does constitute an anticipated constant cost for the present condition of the business.

The executives of a business, in anticipation of a certain income from sales and from other sources, determine the annual appropriation for advertising and other promotional activities. Expenses so budgeted for a given year may be reduced in the following year if anticipated revenues are less, or may be increased if the prospects of increased sales seem to warrant. Accordingly, such expenses are constant at either higher or lower levels for an appreciable range of sales. Thus, expenses of the above kinds are regulated by executive action and are constant in time over a range of output. At any particular time, therefore, they are regulated constant expenses.

Finally, it is to be noted that the constant expenses which may be incurred by a business during any year are of two kinds

Fixed charges
- Cost to possess
- Cost of capital recovery

Regulated expenses
- Conditioned by the nature of the factory and its operations
- Determined largely by executive policy.

2. The *variable expenses* are those which increase or decrease directly with rise or fall in production and sales. The main items of such expenses in mechanical manufacture are material costs, labor costs, and commissions on sales. In the process industries, however, the labor costs, in some instances, do not vary greatly with variations in output. In mechanical manufacture the total *costs of materials* for a month or a year, both materials entering into and becoming part of the product and materials consumed in operations, and the total *costs of labor* for a month or a year, both labor directly associated with productive operations and service labor, are found to vary in a manner closely approximating the rate of production. This is the case particularly because of flexibility in the use of equipment. A department having 100 machines of similar types will operate all these machines when sales demand is high and only, say, 50 machines with half the labor force when sales demand requires 50 percent utilization of capacity. In some cases, in which output varies with a given set-up of the machine because of the cost of the set-up, the labor cost will not vary directly with output. In the process industries, however, the same labor crew must often be maintained to operate the various equipments even though output is only 50 percent of capacity. Accordingly, in the process industries it often happens that total labor cost is the same, or only slightly variable, for a wide range of output. It is also the case in the process industries that the total materials cost for a given output may vary with the "yield," according to the way the processes are operated.

With the exceptions of the situations noted, the costs of materials and labor for a given month or year vary with the output and, for a *given selling price*, with sales of the month or year.

B. CONSTANT AND VARIABLE EXPENSES IN RELATION TO SALES

How these classes of expenses are related to sales may be portrayed graphically, as in the following practical example.

Let us assume for purposes of illustration that a given company * estimates that for anticipated annual sales of $10,000,000 the following total expenses will be in accord (Table XV):

TABLE XV

A TYPICAL BUDGET OF EXPENSE AND PROFIT

1. Materials	$3,300,000
2. Labor	1,400,000
3. Other variable items	300,000
Total variable expenses	$5,000,000
4. Advertising and selling	2,300,000
5. Administration	500,000
6. Interest, insurance, depreciation, local taxes	400,000
7. Other constant items	300,000
Total constant expenses	3,500,000
Total all expenses	8,500,000
Profit from operations	1,500,000

Of the constant total expenses, we find:

Fixed charges	$ 400,000
Regulated expenses	3,100,000

It is also determined, as a matter of executive policy, that these annual constant expenses will be maintained for a sales decline to $9,000,000 and for a sales increase to $11,000,000. The variable expenses are noted to be 50 percent of sales. If these data are plotted, the results are as shown in Figure 14.

The horizontal axis O-X represents annual sales to the scale; one unit equals $1,000,000 annual sales. The vertical axis O-Y represents annual expenses to the same scale as used for the axis O-X.

The point 10 on the X-axis locates sales of $10,000,000. At this point, erect a vertical line and at a distance v_1 from the base representing to scale the $5,000,000 total variable expense locate the point G_1. Then, draw a line from G_1 to the origin O. An ordinate to the line O-G_1 will measure the total variable expenses for any annual sales. For example, if annual sales should be $6,000,000, the total variable expenses should be $3,000,000, as the chart shows.

* Data for this example were derived from the averages of certain food products companies.

Above G locate the point D_1 at a distance f_1, which, to scale, represents the fixed charges of \$400,000. Draw a line through D_1 parallel to O-G_1. This line cuts the Y-axis at F. The ordinate to this line will represent, for any annual sales, the amount of total variable expenses plus fixed charges for such sales. For example, for annual sales of \$6,000,000 the sum of the total variable expenses and the fixed charges

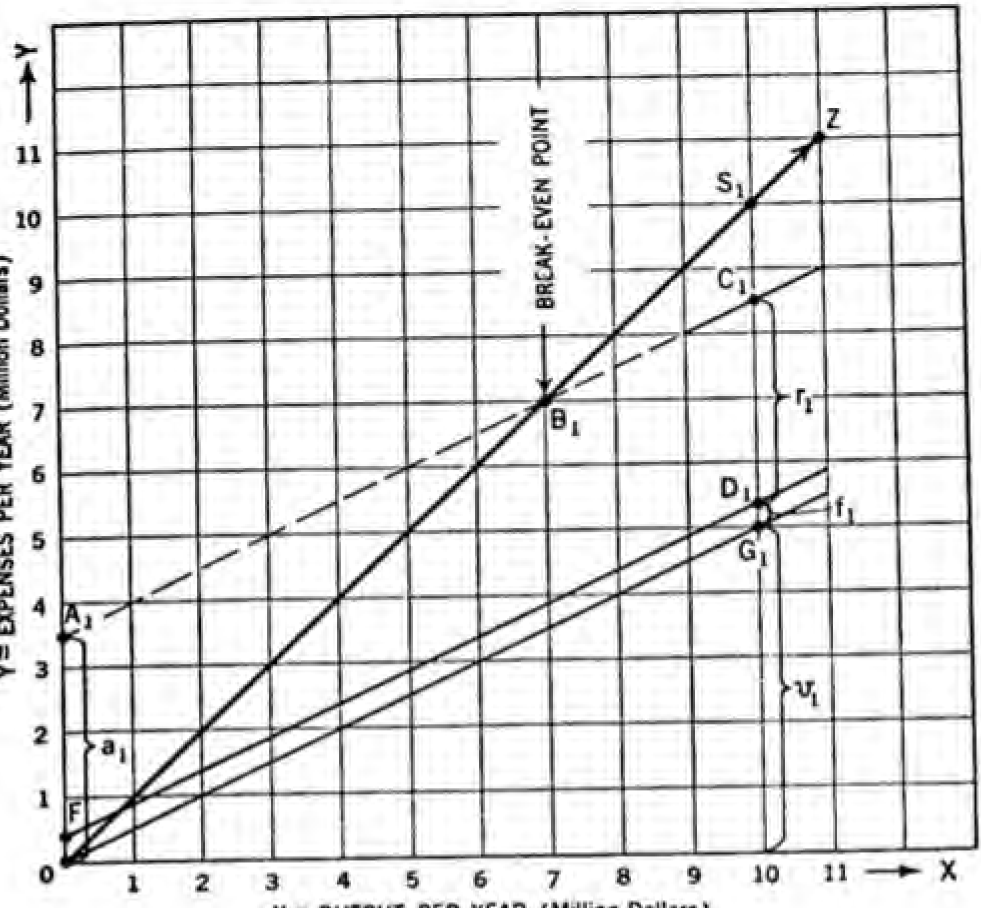

Figure 14. A Typical Break-even Chart

is \$3,400,000. From the point D_1, measure upward the distance r_1, which to scale reads \$3,100,000 (the regulated constant expenses), and locate the point C_1. Draw a line through C_1 and parallel to O-G_1 and where this line cuts the Y-axis, mark that point A_1. This line is drawn full between the verticals for annual sales of \$11,000,000 and \$9,000,000, because the ordinates to the full portion of the line are used to show what the total of all expenses (that is, the total variable expenses plus the fixed charges plus the total regulated expenses) should be for annual sales of any amount between \$9,000,000 and \$11,000,000. The remaining portion of the total expense here is drawn

as a broken line to indicate what the total expense for sales less than \$9,000,000 would be, if the regulated expenses were not adjusted when annual sales became less than \$9,000,000. The line A_1-C_1 shows what the total expenses would be for any annual sales *on the basis of the present budget of expenses.* For example, for annual sales of \$6,000,000 at the present budget of expenses the total of such expenses would be \$6,500,000 and the business would run at a loss of \$500,000. If annual sales should be \$8,000,000, the chart shows that the total expense, if the present budget is maintained, would be \$7,500,000, and the business would operate at a profit of \$500,000. At annual sales of \$7,000,000, the total expenses would be \$7,000,000 and the business would break even. The amount of the annual profit and loss for any sales and the point in sales at which the business would break even may be shown on the chart by the simple expedient of drawing a 45 degree line through the origin, such as the line O-Z. Since the horizontal and vertical scales of the chart are equal, it appears that the ordinates to the 45 degree line from any point of the base are equal in length to the distance of this point from the origin O. For example, the ordinate at the point 10 of the base intersects the 45 degree line at S_1 and expense line at C_1; and 0-10 $=$ (10-S_1). The profit for sales of \$10,000,000 is S_1-C_1 $=$ \$1,500,000. The loss for sales of \$6,000,000 would be \$500,000, according to the chart. Where the 45 degree line crosses the total expense line, the sales corresponding (\$7,000,000 in this case), are the annual sales at which the business is expected to break even, *provided that the budget of expenses for sales from \$9,000,000 to \$11,000,000 is not adjusted.*

But the prudent businessman, if he knows these facts about his business, will regulate his expenses when sales decline and adjust them to lower levels to avoid a loss. If, for example, it is indicated that sales will decline, the businessman will realize that he cannot afford any high constant expenses such as a_1, and therefore he must do something to reduce them. He must review those constant expenses which he can regulate to see what can be done about it. The results of such regulations are shown in Figure 15.

Assume, in this case, that some salaried employees are laid off and other regulated expenses are lowered when annual sales decline below \$9,000,000, and that this reduces the total expenses by \$400,000. Assuming that this reduced total expense is designed to be maintained for annual sales from \$9,000,000 to \$7,000,000, then the total expense line *for this range of sales* would pass through C_2 as shown in Figure 15. If the same policy (of expense reduction) should be adopted for

annual sales between \$7,000,000 and \$5,000,000, then the total expense trend for this range of sales would be defined by the line through C_3 in Figure 15. In practical operations, quite obviously, these lines will really merge into each other because executive decisions are necessarily made in some cases in anticipation of events. Accordingly, as Figure 15 illustrates, by adjusting the regulated expenses for sales be-

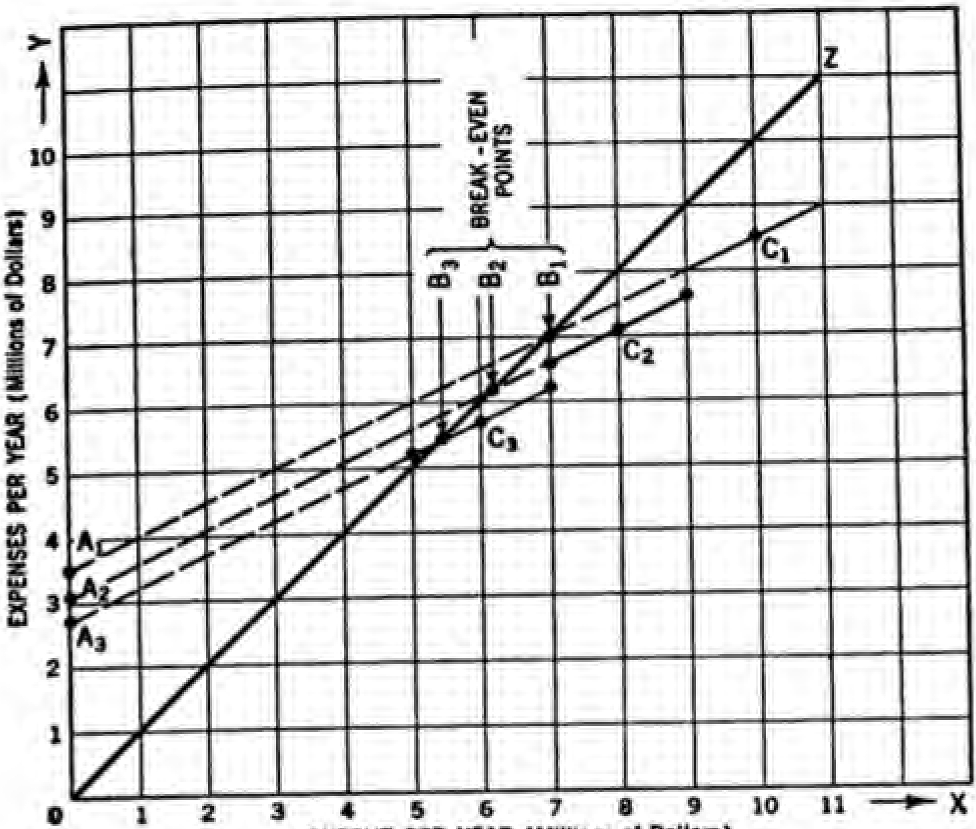

Figure 15. Lowering the Break-even Point by Adjusting the Regulated Expenses

tween \$7,000,000 and \$9,000,000, the break-even point is lowered from B_1 to B_2 and the total constant expenses are reduced from O-A_1 to O-A_2. Likewise, if further adjustments of the regulated expenses are made when it is anticipated that sales will be between \$5,000,000 and \$7,000,000, the break-even point is again lowered to B_3 and the total constant expenses become O-A_3. As noted above, however, these adjustments may be made more gradually with the result that instead of having a series of steps in the total expenses, there results a trend in total expenses along a line connecting the points C_2 and C_3. The mid-points, C_1, C_2 C_3, of the three total expense trends, as above defined, are found to lie on a straight line, as shown in Figure 16, and this

line represents the central trend of total expenses with sales when the policy of adjustment of the regulated expenses is as above described. When the line of central trend is extended until it cuts the Y-axis the intersection K becomes merely a point of orientation of the line of the central trend of expenses and *does not define,* by its distance from the origin k, the constant total expenses of the business at any time.

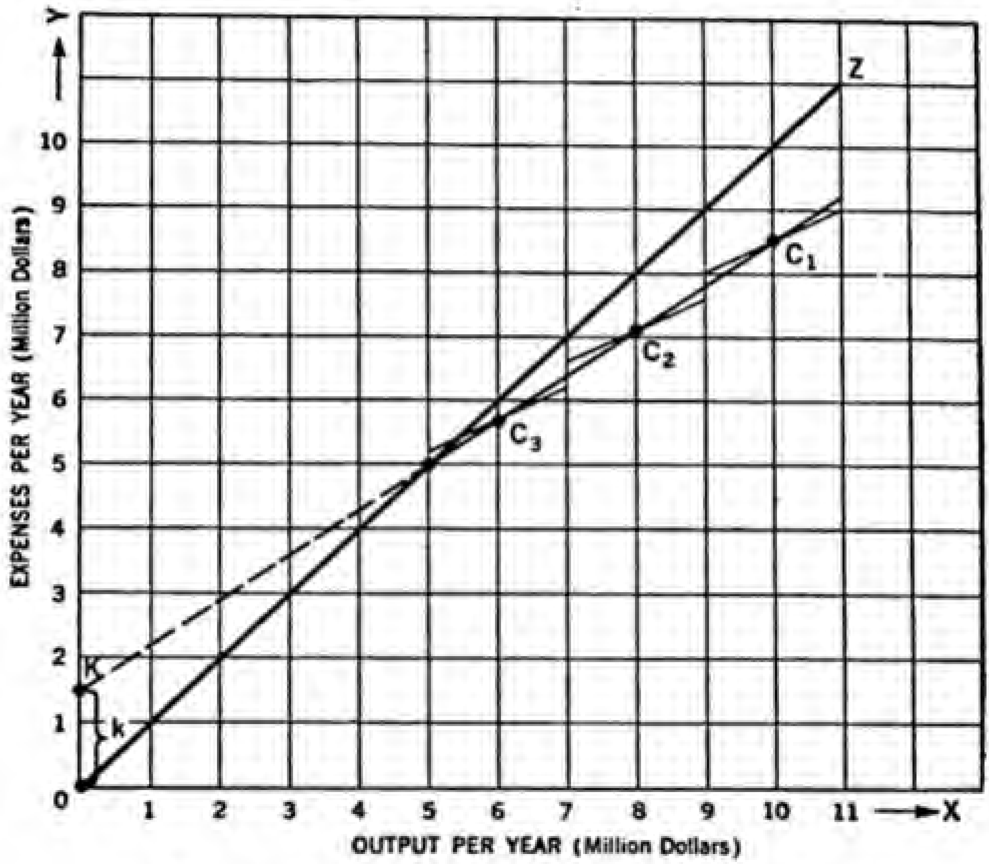

Figure 16. Adjustment of Regulated Expenses

With the above policy of adjustment of the regulated expenses there are three constant total costs, one for annual sales from $9,000,000 to $11,000,000, another for annual sales from $7,000,000 to $9,000,000 and yet another for annual sales from $5,000,000 to $7,000,000. For each of these total costs there exists a different break-even point, as shown in Figure 15.

The point of orientation of the probable line of central trend of total expenses, as sales vary over a wide range, depends on the policy of adjusting the regulated expenses. We will now review the three charts of Figures 14, 15, and 16 to learn their full meaning.

In the first place, it must be noted that the above relationship of expenses to sales is for *sales at constant selling price*. The effect of a change in selling price of the products sold on the *relationship* between expenses and sales will be developed subsequently. In the next place, it is to be noted that all items of expense are based on definitely budgeted expenses for salaries and other items, and for current materials costs and wages rates. The above pattern of relationship is therefore based on the above conditions of unit prices and unit costs. With such a *norm* based on current conditions, it is not only possible to show the probabilities of profit or loss for varying sales income under current conditions of operation but also to show how profit and loss will depart from this norm upon changes in prices and costs of materials and wages.

We will first review Figure 14, which establishes the norm of profit and loss at current prices and costs and at the current expense budget. Here we find that the point A_1, determined as previously described, does show the amount of the total constant expenses of the business under operating conditions (from \$9,000,000 to \$11,000,000 annual sales). The break-even point under these operating conditions can also be predicted by the chart. In this case, it is \$7,000,000. For sales below this amount there will be a loss if the operating budget is not adjusted for lower sales.

It will be noted that the equation of the total expense line A_1-C_1 is of the form

$$\text{Total expense} = y = a + bx$$

where

$a =$ the total constant expenses
$b =$ the ratio of the total variable expenses to sales
$x =$ sales

In this case $$a = \$3{,}500{,}000$$

and $$b = 0.50$$

Thus the total expenses which the business will incur for any sales x is found to be

$$y = \$3{,}500{,}000 + 0.50x$$

It is also to be noted that the 45° line of sales income is of the form

$$y = x$$

When the sales income x is equal to the total expenses y, the business is just breaking even. Accordingly, the business will break even when

$$x = y$$

or

$$x = a + bx$$

that is, when

$$x\ (\text{sales}) = \frac{a}{1 - b}$$

In this case

$$x = \frac{\$3{,}500{,}000}{1 - 0.50} = \$7{,}000{,}000$$

This value is identical with that determined by the chart in Figure 14. Also, the amount of profit or loss to be anticipated for any sales x under operating conditions for $9,000,000 to $11,000,000 annual sales is:

$$P = x - y$$

or

$$P = x - (a + bx) = (1 - b)\,x - a$$

For sales of $10,000,000, it is found that

$$P = \$10{,}000{,}000\ (1 - 0.50) - \$3{,}500{,}000 = \$1{,}500{,}000$$

and for sales of $5,000,000 under current operating conditions

$$P = \$5{,}000{,}000\ (1 - 0.50) - \$3{,}500{,}000 = -\ \$1{,}000{,}000$$

If, as shown in Figure 15, the regulated expenses are reduced to $3,100,000 in the anticipation of a decline in sales from $9,000,000 to $7,000,000, then the business will break even at sales of

$$x = \frac{\$3{,}100{,}000}{1 - 0.50} = \$6{,}200{,}000$$

A further reduction of regulated expenses to $2,700,000 in anticipation of a decline in sales from $7,000,000 to $5,000,000 will result in a break-even point of

$$x = \frac{\$2{,}700{,}000}{1 - 0.50} = \$5{,}400{,}000$$

Since the reductions in regulated expenses in anticipation of declining sales are not usually made abruptly but rather more gradually, the net effect on the *central trend* of total expenses is more nearly as shown in Figure 16, and is along the line C_1-C_2-C_3. How may the

equation of the line C_1-C_2-C_3 be found and how is it to be interpreted? By extending the line to the Y-axis, a point of orientation K is found. The distance k of the point K above the origin is \$1,500,000. *This does not imply that the constant expenses of the business for a range of sales from \$5,000,000 to \$11,000,000 are this sum.* Let this amount O-K be given the symbol k. The slope of the line is found by observation from the chart and is

$$\frac{8{,}500{,}000 - 1{,}500{,}000}{10{,}000{,}000} = 0.70$$

Let this be given the symbol v. The equation of the line is therefore (expense = e)

$$e = k + vx = \$1{,}500{,}000 + 0.70x$$

Accordingly, as a company while maintaining its selling price adjusts its regulated expenses in anticipation of a decline or an increase in sales and such declines or increases eventuate, a line of central trend drawn through the experienced expense points will result in values of k and v as above defined which do not disclose the constant expenses nor the trend of variable expenses as they are budgeted at any particular period in the history of the business. As shown in Figure 15, for example, when sales varied between \$9,000,000 and \$11,000,000, the total constant expenses during that period (expenses which did not vary with sales) were O-A_1 = \$3,500,000; for sales from \$7,000,000 to \$9,000,000, those expenses which did not vary with sales were \$3,100,000; and for sales from \$5,000,000 to \$7,000,000, the company reduced the expenses which were not affected by sales output to \$2,700,000. But the historic pattern of the trend of total expenses with sales over these three periods, as shown in Figure 16, was such that the trend line of total expenses when extended cuts the Y-axis at K and thus defines the point of orientation of the expense line. The quantity O-A_3 of Figure 15, minus the fixed expenses O-F of Figure 14, shows the level to which the regulated expenses were reduced to obtain the break-even point B_3 as shown in Figure 15.

The historic pattern of expense trend must not be confused with the break-even chart at any particular time in the life of a business.

For purpose of clarification, the historic pattern of sales-expense trend experience by a company *over a span of years* (*the Profit and Loss Chart*) will be expressed by the equation,

$$e = k + vx$$

where

e = expense
k = the ordinate of the point of orientation of the trend line
v = the slope of the trend line
x = sales

The sales-expense trend of a company *at any particular time* (*the Break-Even Chart*) will be expressed by the equation,

$$y = a + bx$$

where

y = expense
a = constant total cost
b = ratio of variable total costs to sales

The historic pattern of expenses (materials, labor, factory expense, cost of sales, selling and administration expenses) in relation to sales (the profit and loss chart), particularly for the past several years, should be part of the equipment of every executive office. Indeed, every commercial bank extending credit to any business and every investment banker purchasing the securities of any corporation should have such a graph for every business with which they deal.

The reason is that such a chart shows at a glance the ability or inability of the management to adjust its expenses and prices and to maintain adequate profit margins during the growth of the business. With plant expansion and increasing fixed charges, and with increasing labor and materials costs, the ability of management is severely challenged with respect of maintaining profits over a wide range of sales. Accordingly, the trends of expense in relation to sales, when showing a consistent regularity, generally indicate a capable management.

Departure from established trends, however, may be due to various causes, such as sudden increases in basic costs which can not be compensated for by price adjustments, or to other causes beyond the control of management. It may also be due to additional fixed charges from new plant enlargements, the results of which are not yet balanced by increased sales. Thus the profit and loss chart, properly interpreted, indicates the significant results of past management and the potentialities of the future.

III. THE BREAK-EVEN CHART – IN TERMS OF THE QUANTITY OF GOODS PRODUCED

Break-even charts are of two main types: those in which the X-axis is laid off in terms of dollars of sales, which has just been considered, and those in which the X-axis is laid off in terms of physical quantities of output, which will now be explained. The former is applicable to such companies as manufacture a variety of products. Both the former and the latter are applicable to companies which manufacture a single type of product, such as sugar, steel, lumber, etc., the outputs of which are measurable in physical units. Even those companies manufacturing a variety of products may use the physical unit type of break-even chart for each kind of product.

Both types of charts, the one based on dollar units and the one based on physical units, may be constructed for a business as a whole, for departments of the business, and for each product manufactured.

One of the writers was put in charge of a plant producing a product sold by the pound. The first thing that needed to be done was to determine the break-even chart for current operations. No manager can control a business without a clear picture of the operating characteristics of that which is to be controlled. The annual profit and loss statement of the business, expressed in round numbers, was as in Table XVI.

TABLE XVI

PROFIT AND LOSS STATEMENT

—— Inc.

Net sales		\$2,400,000
Cost of goods sold		
Materials	\$300,000	
Labor	500,000	
Factory expense	800,000	1,600,000
Gross profit		800,000
Adminisuration expense	200,000	
Sales expense	550,000	750,000
Profit from operations		\$ 50,000

The percentage of profit on sales (2.08) was too small. But the statement gives no indication of the constant and variable expenses. To find these classes of expense, each item of the expenses was carefully

analyzed and the following summary of results determined (Table XVII).

TABLE XVII

ANALYSIS OF EXPENSES

Item	Total	Constant	Variable
Material	$ 300,000	——	$ 300,000
Labor	500,000	——	500,000
Factory expense	800,000	500,000	300,000
Administration expense	200,000	200,000	——
Selling expense	550,000	300,000	250,000
Totals	$2,350,000	$1,000,000	$1,350,000

The annual output of product was 800,000 lbs. and the average selling price was 30¢ per lb.

From these data the chart shown in Figure 17 was constructed as follows:

Lay out the base of the chart to the scale 1 unit = 100,000 lb. Lay out the vertical scale at the left of the chart to 1 unit = $100,000. At 8, at the base of the chart, erect a vertical line. On this line locate successively the points M, L, F_1, and S_1 to represent the materials expense M = $300,000; the labor plus materials expenses L = $500,000 + $300,000; the labor plus materials plus the variable portion of factory expense F_1 = $300,000 + $500,000 + $300,000; and S_1 = the variable portion of the selling expense plus material labor and the variable portion of the factory expense—a total of $1,350,000. Lines through these points to the origin show how each item and the total of variable expenses will change with the rate of annual production. The points F_2, A, and S_2, representing the summations of the constant portion of factory expenses, the administrative expense and the constant portion of selling expense are located as shown, and lines through these points and parallel to O-S_1 are drawn. Locate I at a distance of $2,400,000 along the vertical, and draw the line O-I.

The intersection of O-I with the line through F_2 shows that the business will break even before administrative and the constant and selling expenses at B_3 = 385,000 lbs. annual output. At B_2 = 535,000 lbs. annual output, the business will break even before absorbing the constant portion of the selling expense. At B_1 = 760,000 lbs. annual production, all expenses are absorbed. But a 5% price drop would wipe out profits. It appears that for immediate results, improvement in profits could be made by attacking the two largest items of con-

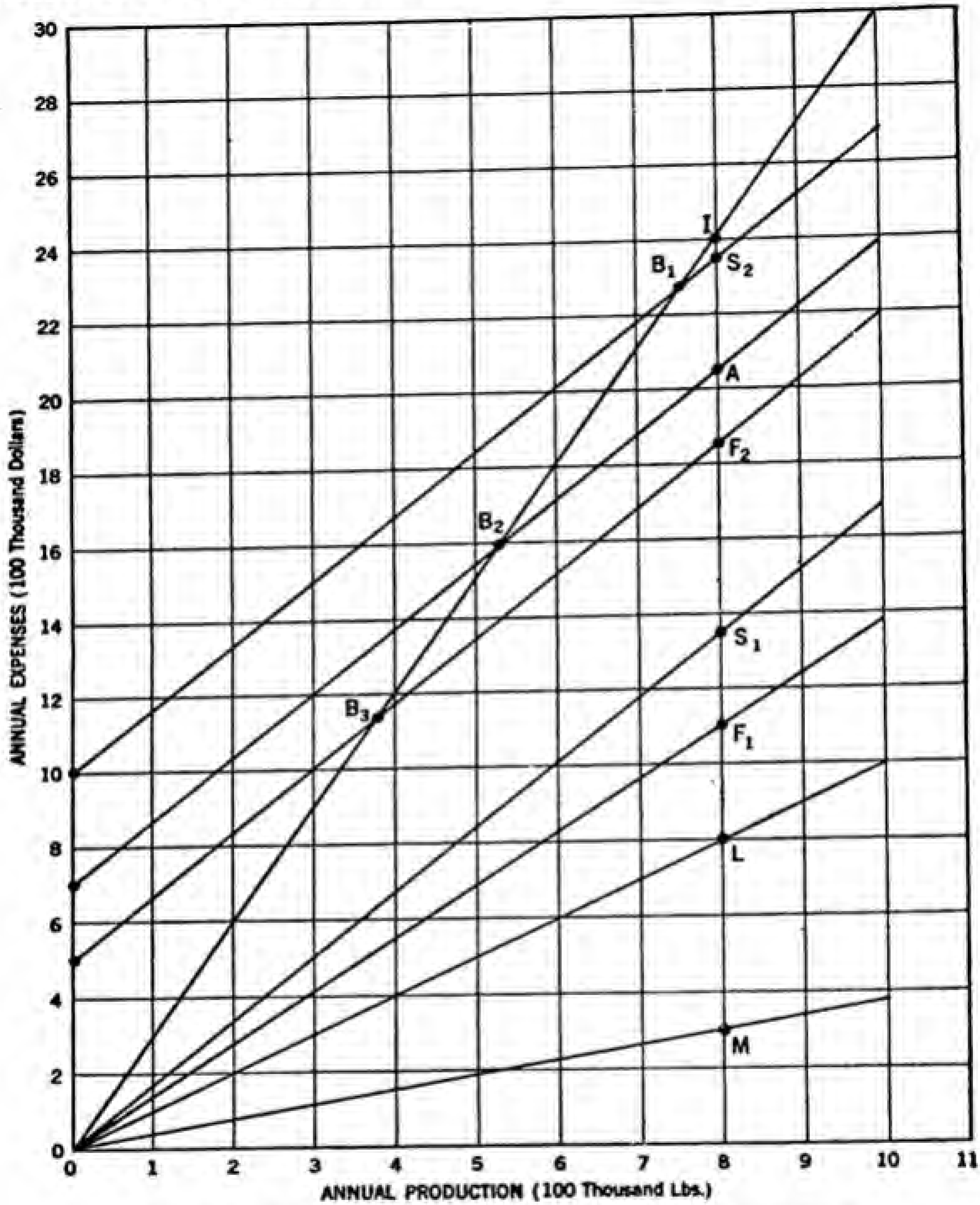

Figure 17. The Break-even Chart for Quantity of Output

stant expenses, the regulated portion of the selling expenses, and the regulated portion of the factory expenses. It was found that the overhead in both manufacture and selling had grown out of proportion to effective results. An intensive study of both these divisions of operation revealed the fact that the manufacturing overhead through

reorganization and reduction of some salaries and personnel could be reduced by $50,000. The promotional expenses of selling and the expenses allowed sales representatives could be reduced by $30,000. This resulted in a total reduction of $80,000.

The new break-even chart, Figure 18, shows that the break-even point has been lowered to 700,000 pounds annual output *at present selling prices* of 30¢ per pound.

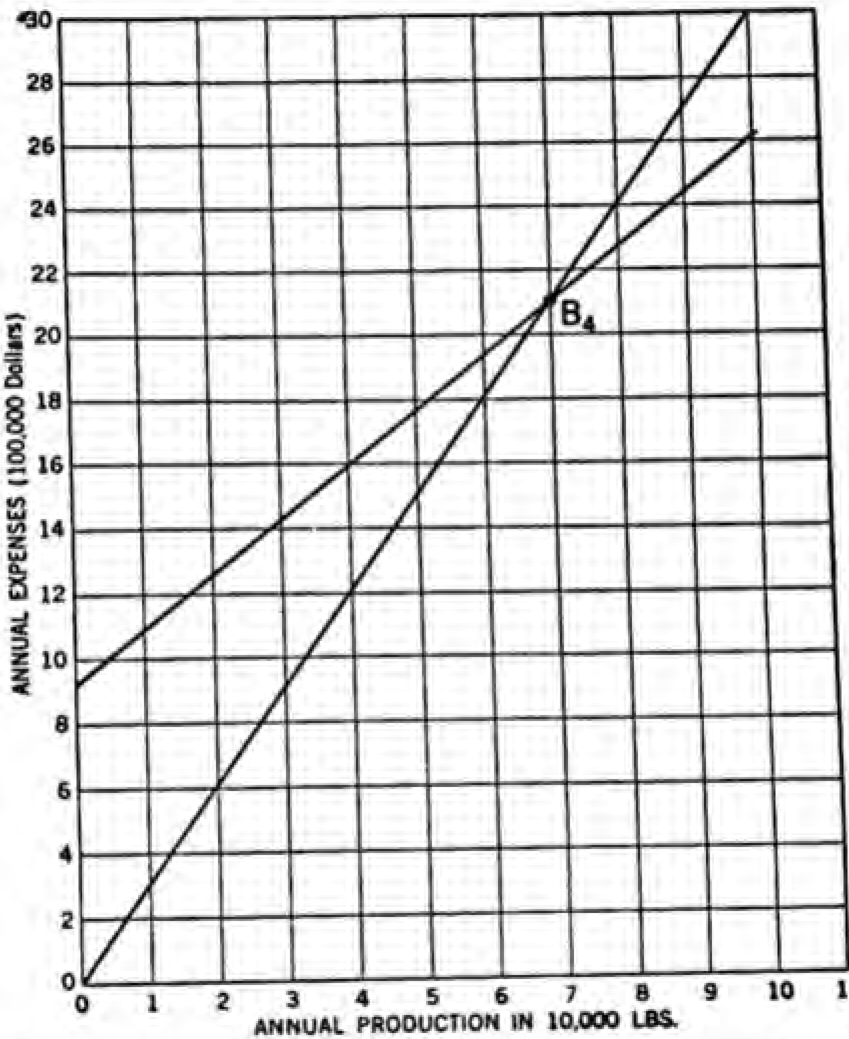

Figure 18. The Break-even Chart of the Same Businesses after Expense Reduction

This accomplishment gave the new management a better margin to work on while tackling other and more difficult problems of reducing expenses through revamping manufacturing operations. This resulted in a further saving of $30,000. The profit potential at present sales was raised from $50,000 per year to $160,000 per year, an increase of 220 percent. In a few minutes of chart construction, the important results

of reorganization are revealed at a glance where many hours' calculation would otherwise be required, *and even then no visualization of results obtained.*

In the next chapter we will show how the break-even chart analysis is used for answering some of the important problems which management faces today.

There has been some discussion of the break-even chart * in the daily press. For instance, the New York *Times,* October 3, 1948, expressed itself on the matter as follows:

> . . . the "break-even chart," which is the invention of Dr. Walter Rautenstrauch of Columbia University . . . discloses the economic characteristics of the whole business process, from the investment of capital to the sale of the final product.

In the same article, Mr. Clinton W. Bennett, President of the National Association of Cost Accountants, was quoted as saying:

> . . . the break-even chart may prove one of the most valuable tools in management's kit.

IV. THE SALES-MIXTURE CHART

The sales-mixture chart was developed shortly after World War II as an aid to the break-even chart. This development resulted from the actual need for dealing with an acute sales-mixture problem in a company where the author was in charge of conducting a thorough break-even analysis.

Today, the multi-product industry is the rule rather than the exception. Most manufacturers are producing an extensive *line of products* rather than a few items.

Because pricing policies are guided by competition as well as by costs, some items are bound to be less profitable than others. Ultimately, profit depends upon the sales mixture as much as upon the total volume of sales.

While the break-even chart analyzes the cost to sales relationship in terms of *sales volume,* it is the purpose of the sales-mixture chart to analyze it in terms of *items sold.*

The sales-mixture chart is based upon a classification of all items by *profit groups.* This classification is often considered as unusual and it

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* See "The Origin of the Break-even Chart" by Raymond Villers in *Journal of Business* of the University of Chicago, Oct., 1955, also *The Dynamics of Industrial Management,* p. 309, note 8.

generally requires some educational effort to have it accepted by all executives concerned. It should be made clear that this classification is intended exclusively for the purpose of sales-mixture analysis and that it will in no way interfere with other classifications used by various departments (for instance: classification of all items by retail price in the sales division or by size, color, or weight in the shipping department or by length of manufacturing cycle in the production division).

Profit groups are determined in accordance with the profit margin per dollar of sales for each item.

In the case where sales are made through different distribution channels, it is advisable to simplify the problem by taking a weighted average so as to determine a single standard selling price for each item.

To determine the profit margin per item, i.e., the difference between the selling price thus determined and the cost of producing the item, it is advisable to apply the direct-costing theory. It would be beyond the scope of this study to describe in detail this theory, which is related to the well-known marginal theory, or to discuss extensively its application to sales-mixture analysis. The reader is referred to another book of this series where special attention is given to the fundamentals of direct costing.* Some applications of the direct-costing theory will be discussed in Chapter XII, section 9.

The direct costs can be defined as those which can be assigned directly to an item and would not be incurred if the item were discontinued. Although there may be some exception, the rule is that such costs are variable in the sense of the classification of costs in fixed, regulated and variable groups previously described in this chapter. Direct costs for a given item include, as a rule, the cost of material and the cost of labor. Some portion of factory overhead and selling expense should also be considered when they can be individualized as direct costs related to a specific item. Let u be the average selling price per unit previously discussed and d the direct cost per item. Then, the margin of direct profit per dollar of sales, which is the basis for the new classification, is:

$$m = \frac{u - d}{u}$$

To illustrate: If in a given manufacturing company item No. 123 is sold to wholesalers at $37 per dozen and to retailers at $40 per dozen and if the sales to wholesalers represent about 62% of total sales while the sales to retailers represent 38%, we will take the weighted aver-

* Villers, *The Dynamics of Industrial Management*, pp. 369ff.

age of \$38.14 as the selling price per dozen, equivalent to \$3.17 per unit. If now the direct costs on this item amount to \$1.52, then the margin of direct profit on each item sold is equal to \$3.17 — 1.52 = \$1.65 and the margin of direct profit on each dollar of sales is equal to this amount divided by the average selling price:

$$m = \frac{1.65}{3.17} = 52.05\%$$

On each dollar of sales related to item No. 123, the manufacturer makes a direct profit of 52.05 cents.

By grouping together the sales of items which bring a comparable direct profit margin—in this case all items which, together with item No. 123, bring more than 50 cents and less than 55 cents of direct profit on each dollar sold—it is possible to add together dollars of sales which have a comparable value in terms of their profitability. This provides a quantitative analysis of the sales mixture.

In actual practice, the range to be adopted for each group depends on the conditions of operations of each business.

In an actual case, the RST Company classifies all items into nine groups, as shown in Table XVIII.

TABLE XVIII
THE RST CO. SALES MIXTURE

Group No.	Average Direct Profit for the Group (*in percent of sales dollar*)	Sales in Dollars		Sales in percent of total sales	
		Budget (*for year*)	Actual (*1st quart.*)	Budget (*for year*)	Actual (*1st quart.*)
(1)	(2)	(3)	(4)	(5)	(6)
1	30	198,500	38,857	1	.91
2	35	595,500	31,598	3	.74
3	40	1,985,000	513,681	10	12.03
4	45	5,161,000	414,617	26	9.71
5	50	1,588,000	514,108	8	12.04
6	55	5,558,000	1,411,235	28	33.05
7	60	2,382,000	791,231	12	18.53
8	65	1,985,000	418,460	10	9.80
9	70	397,000	136,213	2	3.19
	Total	19,850,000	4,270,000	100	100

Col. 2 shows the average direct profit for the group, which in actual practice can also be used as a convenient means of identifying the

group instead of the serial numbers used in Col. 1. In the case of this company, the range of variation per group is 5. Group No. 1 includes all items for which the margin of direct profit is more than 27.5 cents per sales dollar and less than 32.5 cents (average 30 cents per sales dollar). Group No. 2 includes all items for which the margin is more than 32.5 cents and less than 37.5 cents, etc.

For the purpose of sales-mixture analysis the sales of all items of any one group are evaluated in percentage of the total sales for the period under consideration. This provides an abstract measurement which makes it possible to compare the sales-mixture analysis for a given period of time to another period of different length as long as there is no seasonal factor influencing the mixture itself. For instance, in Table XVIII it is possible to compare the actual sales of Group No. 1 for the first quarter of 1956 to the budget for the whole year of 1956. The comparison between the sales figures in dollars ($38,857 and $198,500) would be meaningless, but the comparison between the figures in percent of total sales (.91 and 1) is meaningful (assuming of course that no substantial seasonal variations are expected).

Figure 19 is the sales-mixture chart. The profit groups are plotted in abscissa and the percent of total sales in ordinate. The dotted line represents the budgeted sales mixture, the one that was expected throughout the year 1956 (fifth column in Table XVIII). The plain line represents the actual sales mixture for the first quarter of the year 1956 (sixth column in Table XVIII). It is seen that the pl -line curve is skewed to the right of the dotted-line curve, reflecting the fact that the actual sales mixture was more favorable.

The sales-mixture chart is being used for three main purposes, the last one of which is more specifically related to our present study.

For sales control. A comparison of the actual sales mixture is made to the expected one, as shown in Figure 19. The control of the sales volume is only one aspect of sales control, the other one being the control of the sales mixture.

A sales-mixture chart for each sales district helps in checking whether salesmen, while reaching their quotas in terms of sales volume, are also pushing the profitable items.

For pricing and high-policy decisions. The sales-mixture chart tells where adjustments are seriously needed. The presentation of a sales-mixture chart to management, in a company where it had not been used before, has the advantage of expressing clearly and in quantitative terms a situation which may have been known in general terms but never before thoroughly analyzed and really understood. Prices, thus,

may be changed, production methods reconsidered, some items discontinued, other items promoted more actively, etc. In fact, the writer has had the repeated experience of seeing high-policy decisions of this nature being made by management after a sales-mixture chart was prepared. This was done in cases where the decision, which later on was

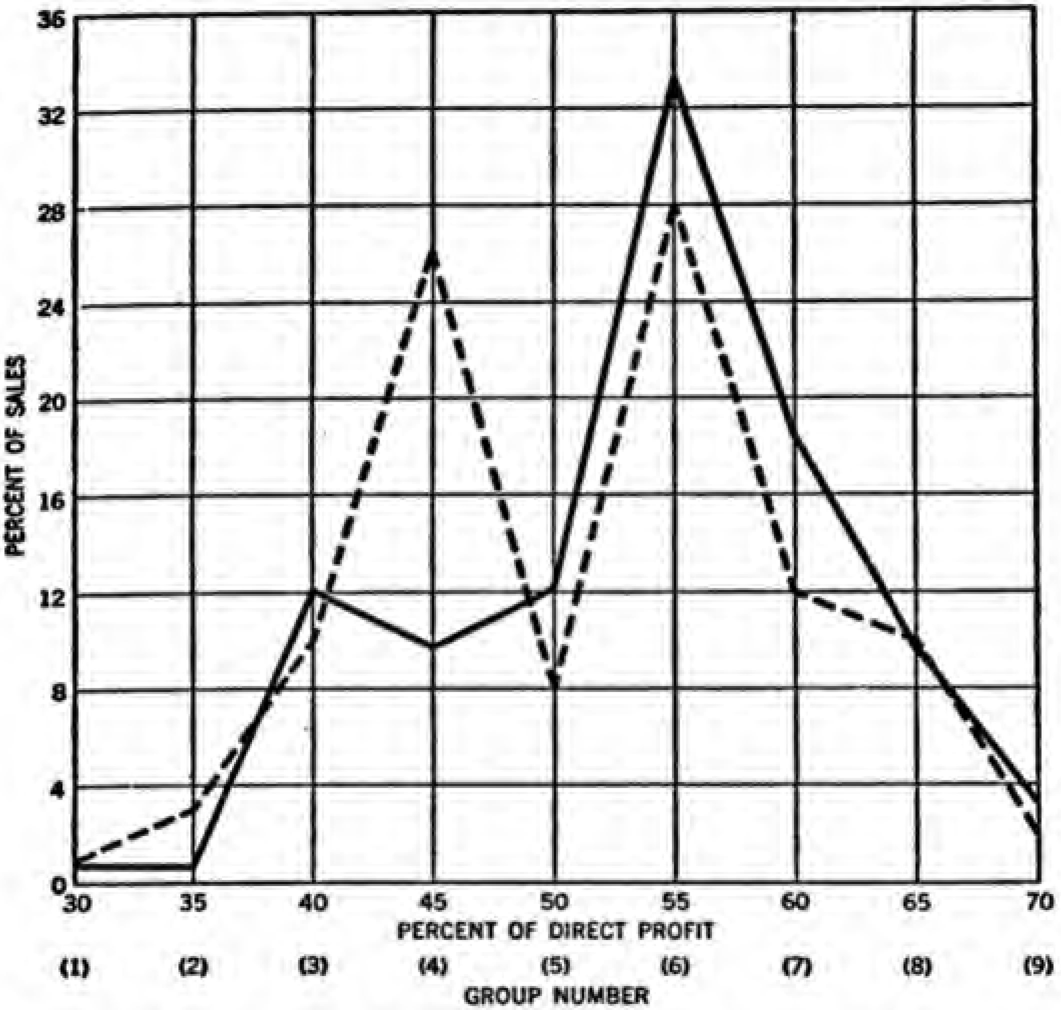

Figure 19. The RST Company Sales-mixture Chart

proved to have been a wise one, would never have been made—nor even taken under consideration—if it had not been for the picture presented by the sales-mixture chart.

For break-even analysis. By preparing sales-mixture charts at regular intervals for the company as a whole, it is possible to detect a change in the sales mixture that affects substantially the total costs to total sales relationship and therefore requires an adjustment of the break-even chart.

If the sales mixture has been analyzed by using the direct-costing

method, as previously described, this adjustment can be made by determining quantitatively the impact of the sales-mixture change upon the ratio variable cost to sales, the b factor of the break-even chart.

Table XIX illustrates the application of the weighted-average principle to effect this measurement.* Col. 1 to 4 of Table XIX reproduces Col. 1, 2, 5, and 6 of Table XVIII. Because the computations required to measure the impact of the sales mixture change are based upon the sales per group expressed in percent of total sales, the dollar value of sales, included in Table XVIII, have been omitted in Table XIX.

Col. 5 and 6 of Table XIX provide for each group and for the total sales a weighted average of the sales mixture (for both budget and actual) in percentage of direct profit and of sales.

TABLE XIX

COMPUTATION OF Δ_b FOR SALES-MIXTURE CHANGE

Group No.	Average direct profit for the group (*in percent of sales dollar*)	Sales in percent of total sales		Weighted average (*by percentage of direct profit & of sales*)	
		Budget (*for year*)	Actual (*1st quart.*)	Budget	Actual
(1)	(2)	(3)	(4)	(5)	(6)
1	30	1	.91	30	27.3
2	35	3	.74	105	25.9
3	40	10	12.03	400	481.2
4	45	26	9.71	1170	436.95
5	50	8	12.04	400	602
6	55	28	33.05	1540	1817.75
7	60	12	18.53	720	1111.8
8	65	10	9.80	650	637
9	70	2	3.19	140	223.3
	TOTAL	100	100	5155	5563.20
	Total direct profit per dollar of sales (in cents)			51.55	55.63
			Δ_{b_m}	$-\frac{4.08}{100}$	

The computations show that the sales mixture, as budgeted, would have brought a direct profit of 51.55 cents per dollar of sales and that

* For a detailed study of the problem and the discussion of a related but different approach, see Fields, David S., "Sales Mixture Control," *The Controller*, May, 1955.

the actual sales mixture for the first quarter brought a direct profit of 55.63 cents per dollar of sales.

These computations indicate an *increase* in direct profit, which means a corresponding decrease in the ratio variable expense to sales, the b factor of the break-even chart. This decrease is:

$$\Delta_{b_m} = -\frac{P_{m_1} - P_{m_0}}{100}$$

where Δ_{b_m} is the difference in b due to the change in the sales mixture, P_{m_1} the direct profit in cents per dollar resulting from the new mixture, P_{m_0} the direct profit in cents per dollar resulting from the original mixture. In this case

$$\Delta_{b_m} = -\frac{55.63 - 51.55}{100} = -\frac{4.08}{100}$$

This difference can then be incorporated into the equation of the break-even chart:

$$y = a + bx$$

by using the method of differential profit control to be now described.

V. DIFFERENTIAL PROFIT CONTROL *

In recent years increasing attention has been given to the advantages of using mathematical concepts for the purpose of profit maximization. New methods of mathematical programming have been proposed. Many of them require such involved computations that they would be totally unrealistic if it was not for the fact that new tools have been made available for performing such computations. In this respect, as in many other fields, the development of electronic computers has opened entirely new horizons.

Up to now it seems that the mathematical methods that have received the greatest attention, have been, as a whole, directed toward the maximization of the profit related to *specific operations*, such as the determination of the most economical production lot size, or the determination of the most economical method of delivery of goods

* This method was originally described by the writer in a paper presented before the Seventh National Convention of the American Institute of Industrial Engineers at Washington, D.C., May, 1956. This paper was based upon several years of research undertaken in industrial corporations whose managements were specifically concerned with the problem of sales-mixture control and break-even analysis. See also the writer's article in *Journal of Industrial Engineering*, July-August, 1957.

from warehouses spread all over the country, or the determination of the most economical scheduling in a given plant or part of a plant.

Obviously the solution of such specific problems (to which we will return in Chapter XIII) deserves full attention. The way to maximize total profit is, in good logic, to start by maximizing profit for each or some of the specific factors which influence total profit. At the same time, it is not always true that the summation of specific maximizations effected independently from each other will necessarily and automatically result in total profit maximization. After all, the industrial enterprise, in spite of its great complexity, constitutes a single entity. This means that no specific step can be taken without somehow involving the whole enterprise, directly or indirectly. Maximization of a specific element of profit may well, in final analysis, be overcompensated by a substantial decrease of profit somewhere else. The far-reaching implications of any specific decision are not always easy to foresee.

There is another fundamental reason for basing profit maximization upon an over-all picture. It is the fact that every specific decision is always, directly or indirectly, made possible by high-policy decisions. These, in turn, are, by definition, based upon an evaluation of the over-all picture of the whole situation.

To illustrate: On April 15, 1957, some steps are taken in Dept. 37 of a given manufacturing company. These steps will result in substantial cost-reduction in the manufacturing of Item 567. This is a case of specific profit maximization. But the steps that have been taken were made possible only because, among other factors, Mr. X., the industrial engineer who recommended them, had been hired following the high-policy decision to create an industrial engineering department. This high-policy decision taken in 1956 by the board of directors involved an increase of total overhead before it resulted in specific profit maximization. It was a necessary prerequisite to the specific cost-reduction arrived at in Dept. 37 on April 15, 1957, with relation to the manufacture of Item 567.

This illustrates the fact that profit maximization requires that attention be given to the "synthetic approach" as well as to the "analytic approach." Actually, the two approaches complement each other.

This fact is, of course, fully recognized in industry. This is why profit control is traditionally based upon the simultaneous use of cost accounting, i.e., the *analytic approach*, and general accounting, i.e., the *synthetic approach*.

Most of the new concepts which are using mathematical methods for the purpose of profit maximization relate to specific operations.

They follow the analytic approach. As such they can be considered as a sort of modernization of cost accounting.

There seems to be also an opportunity of stimulating the modernization of general accounting by following the synthetic approach in using mathematical concepts to maximize total profit.*

The method to be now discussed is intended to be a step in this direction. It is based upon difference computations and for this reason can be called a method of *differential profit control.* It is an attempt to provide a greater flexibility in the preparation and the use of the break-even chart, whenever such a flexibility is required by the complexity of the conditions of operations. Essentially it amounts to the preparation of what can be called a *differential break-even chart.*

To illustrate the principles involved, let us take the RST Co. For the year 1956, the profit and loss statement of the company shows the following results (in millions of dollars):

Total sales		15.0
Cost of goods sold	10.0	
Selling expense	2.0	
Administrative expense	1.5	
Total expense		13.5
Net profit before taxes		1.5

Let us say that the analysis of cost provides the following figures:

Labor	3.0		
Material	5.0		
Other variable costs	2.0		
Total variable		10.0	
Total constant		3.5	
Total cost			13.5

As previously shown, the trend expense to sales is defined by the linear equation:

$$y = a + bx$$

* A similar statement is made in a recent article that there is a need for giving more attention to the general rather than the specific business problems in applying mathematical methods. The author of this article is also using the break-even chart as the basis of his research work although following a different approach than the one to be now described. See "Multiple Factor Break-even Analysis: the Application of Operations Research Techniques to a Basic Problem of Management Planning and Control," by Robert Stanley Weinberg, in *Operations Research*, Vol. 4, No. 2, 1956.

where

$y =$ total expense
$x =$ total sales
$a =$ constant expense
$b = \frac{v}{x} =$ ratio variable expense to sales for the period under consideration.

In this case $a = 3.5$; the variable expense for $x = 15$ is $v = 10$; thus $b = \frac{10}{15}$ and the trend expense to sales of the RST Co. for the year 1956 is:

$$y = 3.5 + \frac{10}{15}x = 3.5 + .66x$$

This equation is valid only within a certain range of variation of the volume of production and only as long as the conditions of operation remain unchanged, as previously discussed.

If at any time the annual sales of the RST Co. increase from $15 to 20 millions, the variable expense v increases from $10 millions to $v = .66x = .66 \times 20 =$ $13.2 millions. Certain elements of constant expense, the supervisory expense, for instance, and a few others, will have to be increased. If their total increase was to be .3, then $a = 3.5 + .3 = 3.8$ and the equation y becomes:

$$y = 3.8 + .66x$$

In this equation, the factor a has changed but the factor b has remained unchanged. But if, in addition, some progress is made in methods and processes which increase labor efficiency, then the slope of the trend decreases.

If there should be a change in the sales mixture, the slope of the trend is further modified, and the factor b must be recomputed before drawing the new break-even chart.

Do these considerations affect the usefulness of the break-even chart? Certainly not, as well proved by its increasing adoption in industry.*

* The increasing interest of industrial executives in graphical representation for the purpose of profit control, and more specifically their interest in the three charts that have been discussed in this chapter, is illustrated by the fact that leading magazines and publications known to be read by these executives have, in recent years, given increasing attention to these methods. See for instance: *Dun's Review and Modern Industry* (Nov., 1955); Am. Management Assoc., *Manufacturing Series No. 207* (Jan., 1953); *Business Week* (July, 1949); *Fortune* (Feb., 1949); *Modern Industry* (Dec., 1948); New York *Times* (Oct. 3, 1948).

Its usefulness results essentially from two characteristics:

1. The chart provides a linear equation which defines the cost to sales relationship within a certain range of variation of the volume of production and which remains valid as long as the conditions of operation remain unchanged.
2. When this range of variation of the volume of production is exceeded and/or when the conditions of operation change, the chart provides the basis from which the impact of a change can be measured.

The purpose of the method of differential profit control is to take full advantage of these two characteristics by combining them into one single mathematical model which will provide both the linear equation that defines the cost to sales relationship and the structure within which computations can be made in a comparatively simple manner to measure the impact of a change. This mathematical model is the equation:

$$y = (a + \Delta_a) + (b + \Delta_b)\,x$$

where

$y =$ cost
$x =$ sales

$$a = \sum_{i=1}^{N_0} a_i$$

where $a_1, a_2, \ldots aN_0$ are the original elements of constant costs that have been recorded at the time T_0 of the original analysis and correspond to the period considered at this time, for instance, the supervisors' salaries.

$$\Delta_a = \sum_{i=1}^{N_0} \Delta_{a_i} + \sum_{i=N_{0+1}}^{N_1} a_i$$

where $\Delta_{a1}, \Delta_{a2} \ldots \Delta_{aN_0}$ are the differences due to a change in the value of the original elements of constant costs (a_1, $a_2, \ldots a_{N_0}$) (for instance, an increase in supervisors' salaries);

where $a_{N_{0+1}}, a_{N_{0+2}} \cdots a_{N_1}$ are the additional elements of constant costs that have been recorded during the period T_0 to T_1, T_1 being the time of the subsequent analysis. For instance, the depreciation of a new piece of equipment.

$$b = \frac{\sum_{i=1}^{N_0} v_i}{x_{T_0}}$$

where $v_1, v_2, \ldots v_{N_0}$ are the original elements of variable cost that have been recorded at the time T_0 and correspond to the period considered at this time; for instance, the cost of materials during this period

where x_{T_0} is the volume of sales corresponding to this same period.

$$\Delta_b = \Delta_{b_{m_{T_1}}} + \frac{\sum_{i=1}^{N_0} \Delta_{v_i} + \sum_{i=N_{0+1}}^{N_1} v_i}{x_{T_1}}$$

where $\Delta_{b_{m_{T_1}}}$ is the difference due to a change in the sales mixture, which change occurred during the period T_0 to T_1 and was determined at the time T_1 by following the method previously described; *

where $\Delta_{v_1}, \Delta_{v_2}, \ldots \Delta_{v_{N_0}}$ are the differences in variable costs which are related to a change in the structure of the original elements of variable costs ($v_1, v_2, \ldots v_{N_0}$) and occurred during the period T_0 to T_1 (for instance, an increase in the price of material);

where $v_{N_{0+1}}, v_{N_{0+2}}, \ldots v_{N_1}$ are new elements of variable costs that have been recorded during the period T_0 to T_1 (for instance, the introduction of a pension plan for the labor force);

where x_{T_1} is the volume of sales corresponding to the same period T_0 to T_1.

Later on, as subsequent analyses are made at the times $T_2, T_3, T_4 \ldots T_n$, then:

$$\Delta_{a_{T_n}} = \sum_{i=1}^{N_{n-1}} \Delta_{a_i} + \sum_{i=N_{(n-1)+1}}^{N_n} a_i$$

$$\Delta_{b_{T_n}} = \sum_{i=T_1}^{T_n} \Delta_{b_{m_i}} + \frac{\sum_{i=1}^{N_{n-1}} \Delta_{v_i} + \sum_{i=N_{(n-1)+1}}^{N_n} v_i}{x_{T_n}}$$

* See above page 116.

until such time that it is decided to incorporate Δ_a and Δ_b into a and b respectively and start a new series. This can, for instance, be done at the end of a year or after the completion of a project involving substantial changes in the conditions of operations.

Attention should be called to the fact that until such time, the computation of the ratio variable to sales, the b factor, in addition to an evaluation of the difference Δ_{b_m} due to a change in the sales mixture, requires a careful assignment of the elements of variable cost related to the volume of sales which actually correspond to the period considered. In other words:

$$b + \Delta_b = b + \left[\Delta_{bT_1} + \Delta_{bT_2} + \cdots + \Delta_{bT_n}\right]$$

$$= \frac{\sum_{i=1}^{N_0} v_i}{x_{T_0}} + \left[\sum_{i=T_1}^{T_n} \Delta_{b_{m_i}} + \frac{\sum_{i=1}^{N_0} \Delta_{v_i} + \sum_{i=N_0+1}^{N_1} v_i}{x_{T_1}} + \frac{\sum_{i=1}^{N_1} \Delta_{v_i} + \sum_{i=N_1+1}^{N_2} v_i}{x_{T_2}} + \cdots + \frac{\sum_{i=1}^{N_{n-1}} \Delta_{v_i} + \sum_{i=N_{(n-1)}+1}^{N_n} v_i}{x_{T_n}}\right]$$

Depending upon the circumstances, the period considered at any time T_n may be a year or a month, may be related to past experience or future expectations. The determination of the period is needed to establish the ratio variable to sales, but after the trend has been defined, the equation applies to any other period, past, present or future.

This approach simplifies the computations needed for profit control as will now be shown. If we consider the equation of differential profit control

$$y = (a + \Delta_a) + (b + \Delta_b)\,x$$

we see that it includes two groups of factors.

First group includes the two basic factors a and b. The determination of a and b requires a detailed analysis of the expense accounts, which must be classified either as constant or as variable. It sometimes requires breaking down an account into a variable and a constant section. It generally requires rather lengthy computations.* By following the method of differential profit control it will still be necessary to perform these computations at the time of the original analysis but it will be

* See Villers, *The Dynamics of Industrial Management*, p. 333.

possible to avoid repeating them. At the time of subsequent analyses, computations, as a rule, will be limited to the second group.

Second group includes the difference factors Δ_a and Δ_b which will be computed as often as necessary. The control of Δ_a is based upon the fact that a change in the constant expense, by definition, requires managerial action. A change in supervisory expense, for instance, may be related to the volume of sales, but it does require specific action. In fact, in a well-budgeted company, such changes call for an adjustment in the budget. The computation of Δ_a can therefore be based upon the fact that such changes are recorded. They can be detected as a matter of routine of control. Their impact can be computed if and when they occur.

The same is true for most of the changes influencing Δ_b.

A mere change in the volume of production may occur so often and so irregularly that it would escape routine recording. The fact is, however, that such a change affects only the variable expense, not its ratio to sales. Hence it does not influence Δ_b.

A change in the conditions of operations, such as wage increase or decrease, material price fluctuation, improvement in labor efficiency, does affect the ratio of variable expense to sales. It therefore must be computed as part of Δ_b. As a rule, it can be said that such changes require specific managerial action at one or another level of management. This means that they are recorded somewhere. Thus, they can be detected as a matter of routine of control in the same manner as changes affecting Δ_a. Their impact can be computed if and when they occur.

Another change that influences Δ_b is a change in the sales mixture. Contrary to a change in the conditions of operations above mentioned, a change in the sales mixture is not necessarily the result of a recorded managerial decision. With due exception for specific cost changes or for high-policy decisions introducing new items, or changing prices, discontinuing some production or modifying the production characteristics of established items, a change in the sales mixture is, as a rule, the result of the random effect of the sales effort. But the impact of a change in the sales mixture can be periodically determined by following the method previously described * for the measurement of Δ_{b_m} (the difference in the ratio of variable expense to sales due to such a change).

The difference Δ_{b_m} can then be added to all other differences affecting this ratio: $\Delta_{b_1}, \Delta_{b_2}, \Delta_{b_3} \ldots \Delta_{b_n}$.

* See above page 116. Whenever an item is moved from a profit group to another one, because of a change of pricing or direct costs, an adjustment should be made to avoid duplicating Δ_{b_m} with another Δ_b ($\Delta_{b_1} \ldots \Delta_{b_n}$).

The use of the method of differential profit control for the preparation of the break-even chart can be illustrated by using some precise figures. Let us return to the case of the RST Co. as a basis for discussion.

As shown on page 119, sales and cost figures for the year 1956 are:

Net Sales			\$15.0 million
Labor	3.0		
Material	5.0		
Other variable cost	2.0		
Total variable		10.0	
Total constant		3.5	
Total cost			13.5
Net profit			1.5

Therefore, the equation of differential profit control for the company as of Jan. 1, 1957, based upon the conditions of operations at the time is:

$$y = (3.5 + \Delta_a) + (.66 + \Delta_b)\,x$$

At the end of the first quarter, 1957, a break-even analysis is being conducted on the basis of the following changes that have occurred and have been duly recorded, as they did occur:

A. *Changes affecting the constant expense* (computed in millions of dollars on the basis of annual rate of expense)

1. Because of an increase in production, which has brought production up to \$4.8 million for the first quarter, 1957, and is expected to increase further during the year, the supervisory force has been increased.

$$\Delta_{a_2} = .03$$

2. For the same reason, maintenance cost has been increased

$$\Delta_{a_6} = .001$$

3. The Board of Directors has increased advertising by

$$\Delta_{a_{14}} = .05$$

4. Four new items of constant expense have been introduced. One is the rent of a new warehouse

$$a_{101} = .04$$

The second one is the interest on a long term loan that was required because of lack of working capital to face the increase in production and amounts to

$$a_{102} = .06$$

The third one results from the creation of a research department

$$a_{103} = .05$$

The fourth one results from the introduction of a pension plan for monthly paid employees

$$a_{104} = .04$$

B. *Changes affecting the ratio variable expense to sales*

1. *Change in the rate of variable expense* (expressed in percent of sales)
   a. An incentive plan and some improvement in the methods of work have resulted in an increase of about 10% in labor efficiency. As labor is $\frac{3}{15} = 20\%$ of sales, such an increase in labor efficiency means a reduction of labor cost of about 2% of sales. Thus

$$\Delta_{b_1} = -\frac{2}{100}$$

   b. The increase in production has been made possible by a special sales effort related to the increase in advertising expense already recorded. This effort also included an increase in salesmen's commissions and in their traveling expense budget, resulting in

$$\Delta_{b_{23}} = \frac{4}{100}$$

2. *Changes in the sales mixture*

   The sales mixture has been affected by a trend favoring the sales of less profitable items. Its analysis shows a *decrease* in profitability of 4.1 cents per dollar of sales equivalent to an *increase* in the ratio variable expense to sales:

$$\Delta_{b_m} = \frac{4.1}{100}$$

C. *Impact of the changes—Differential profit control*

Summarizing the above computations, it is seen that in the equation

$$y = (3.5 + \Delta_a) + (.66 + \Delta_b)x$$

We find

$$\begin{aligned}\Delta_a &= \Delta_{a_2} + \Delta_{a_6} + \Delta_{a_{14}} + a_{101} + a_{102} + a_{103} + a_{104}\\ &= .03 + .001 + .05 + .04 + .06 + .05 + .04\\ &= .271\\ \Delta_b &= \Delta_{b_m} + \Delta_{b_1} + \Delta_{b_{23}}\\ &= \frac{4.1}{100} - \frac{2}{100} + \frac{4}{100}\\ &= \frac{6.1}{100}\end{aligned}$$

Thus, the equation of the break-even chart of the RST Co. as of the end of the first quarter, 1957, is:

$$\begin{aligned}y_1 &= (3.5 + .271) + (.66 + .061)x\\ &= 3.771 + .721x\end{aligned}$$

D. *Differential break-even chart*

The above computations are only an illustration of those that have to be performed in actual practice to keep abreast of changes in conditions of operations.

By using the break-even chart, it is possible for the departments in charge of making such extensive and sometimes intricate computations to present to the executives in charge of making decisions a clear and simple picture of a given situation.

Figure 20 is the differential break-even chart corresponding to the above computations.

Trend 1 corresponds to the original equation (as of Jan. 1, 1957):

$$y_0 = 3.5 + .66x$$

Trend 2 corresponds to the new situation (as of April 1, 1957):

$$y_1 = 3.771 + .721x$$

The use of dotted and plain lines as shown in Figure 20 is advisable, because it illustrates the volume at which the change occurs.

By looking at this single graph instead of going over intricate computations which have been made by trained clerks, an executive can see at a glance the impact of a series of changes in the conditions of operations. Measurements on the graph itself give an immediate answer to such questions as:

1. What happened to the break-even point?
   Ans.—It was raised from \$10.3 million to \$13.5 million.

2. Are we in a better or in a worse position than before?
   Ans.—Despite the fact that our trend of relationship cost to sales is definitely less favorable we are likely to make more profit. Our net profit for 1956 was \$1.5 million. On the basis of present conditions of operations we can expect for the year 1957 a total volume of sales of \$20 million, resulting in a profit of about \$1.8 million, an increase in net profit of \$300,000

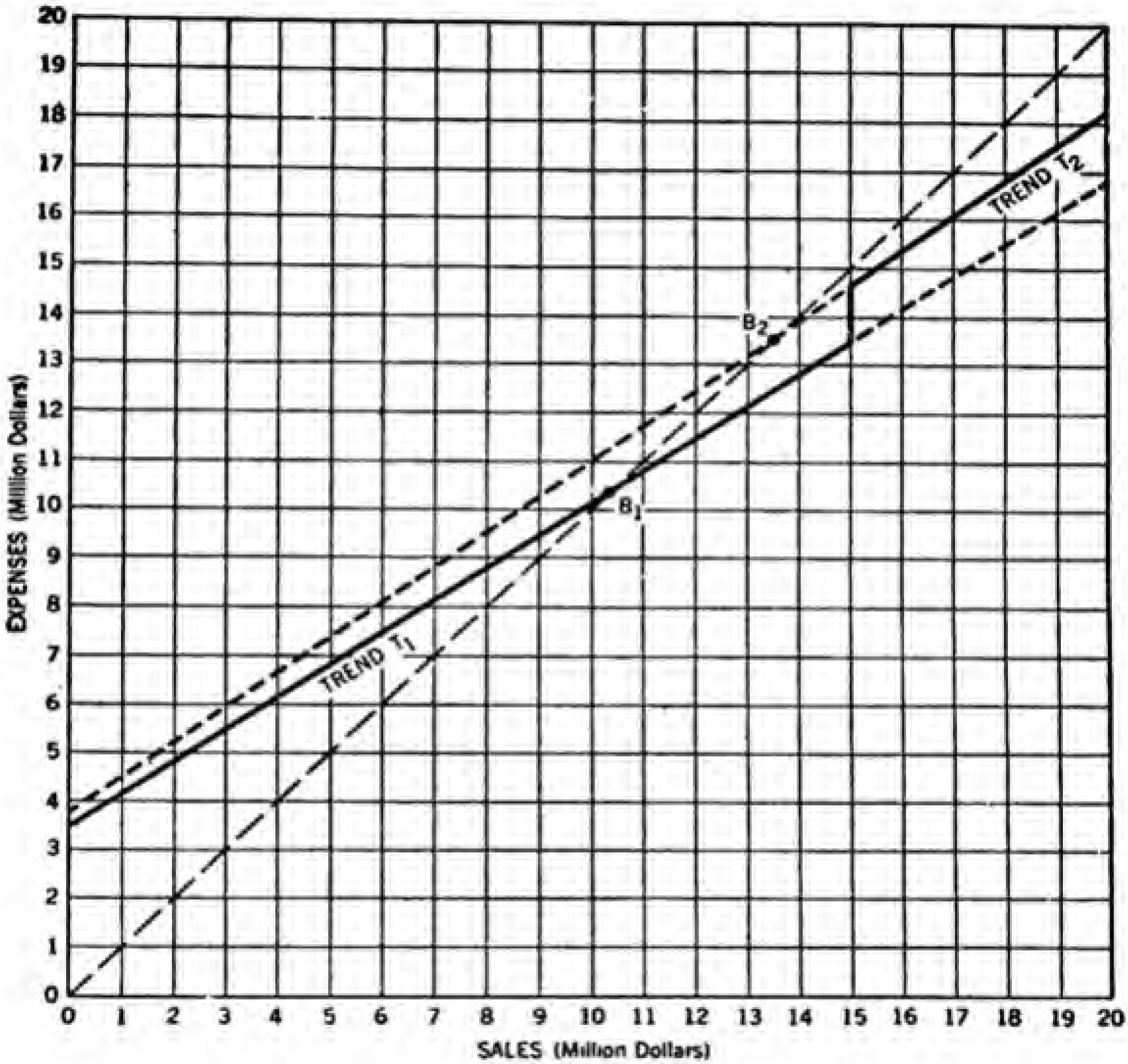

Figure 20. The RST Company—Differential Break-even Chart

Furthermore the same chart can be used to show the impact of any kind of change under consideration by merely plotting the trend corresponding to the situation that would thus be created. The new trend is determined by using the present trend as the basis from which to start and evaluating any expected difference. In the case illustrated in Figure

20, if further changes related to high-policy decisions were to be considered, the trend T_2 would be considered as the basis. The impact of contemplated changes would be determined by evaluating the differences Δ_a and Δ_b in the equation

$$y = (3.771 + \Delta_a) + (.721 + \Delta_b)x$$

In the following chapters we will see how such changes can be evaluated by simply using graphical methods when the problems under consideration warrant this simplified approach.

In the case where electronic computers are being used for accounting purposes, as discussed in Chapter I, the method of differential profit control reviewed in the present chapter can be incorporated into the writing of an accounting program. Such a procedure is simplified whenever the chart of accounts provides for the recording of variable expenses and the recording of constant expenses in separate expense accounts, as is often being done in progressive companies.*

The program should call for summarizing all differences in constant expense due either to a change in the original elements of constant expense ($\Delta_{a_1} \ldots \Delta_{a_{N_0}}$) or to the introduction of newly recorded elements of constant expense ($a_{N_{0+1}} \ldots a_{N_1}$), and for computing Δ_b, the difference in the ratio of variable expenses to sales, due either to a change in the sales mixture (Δ_{b_m}) or to a change in the structure of the original elements of variable cost ($\Delta_{v_1} \ldots \Delta_{v_{N_0}}$) or to the introduction of newly recorded elements of variable cost ($v_{N_{0+1}} \ldots v_{N_1}$). Thus the program can provide at any selected time a summarization of all changes affecting the characteristics of the business since the last computation of a and b.

In short, although large corporations may have a high "speed of economic flow" and a vast number of accounts, as already emphasized in Chapter I, it appears that the over-all impact of changes can be evaluated in terms of a thorough break-even analysis through the use of electronic computers and their suitable programming.

* For a discussion of such an improvement of the charts of accounts, see *The Dynamics of Industrial Management*, pp. 236*ff*. and 326*ff*.

V

CHARTS OF BUSINESSES AND INDUSTRIES

PROFIT AND LOSS CHARTS can be easily prepared for any American business by using the data generally available to the public in the annual reports to the stockholders, the reports of the Securities and Exchange Commission, and Moody's *Industrial Manual*, available in most libraries. The consolidated data for whole industries are published quarterly in the *Financial Report for Manufacturing Corporations* issued jointly by the Federal Trade Commission and the Securities and Exchange Commission. The data for constructing break-even charts, on the contrary, are of a more confidential character. Only high-ranking executives normally have access to the accounts which show the break-down of expenses in their constant (fixed and regulated) and variable components. In the following pages, the profit and loss charts of various businesses, and of whole industries, are prepared from data which are generally available through the sources that are noted above.

The data for the break-even charts have been provided from confidential sources, whose origin must necessarily remain anonymous.

I. PROFIT AND LOSS CHARTS

We have prepared several hundred profit and loss charts of many companies and for whole industries, selected examples of which are given below.

In each case, a table will report the accounting data and a figure will show the corresponding profit and loss chart. To simply compare the chart to the table is, by itself, meaningful. It illustrates the fact that five, ten, or twenty years of financial management, instead of being presented as an unattractive mass of accounting data almost totally unrelated to each other, can be visualized as a profit and loss chart and interpreted in terms of one or by a few single linear equations, each of which defines a long-range trend.

At this point, the fundamental questions are of course: How reliable are the trends thus determined? Why are they more accurate than the mere ratios which are often used for a similar purpose? To what extent can these trends be considered as standards by which past profits can be measured and on the basis of which future profits can be forecast in relation to anticipated sales?

The answer to such questions can be given in quantitative terms by studying for given cases the variance between the actual expense and the standard expense, the latter being determined by using the profit-and-loss-chart trend. Table XX presents such a study, conducted for a few selected cases. The period of 1950-55 was selected as being the most recent period for which data were available at the time this revised edition was prepared. The companies listed have been selected at random among well-established companies of various sizes, operating in various fields.

The equation used in each case is the one determined on the basis of the profit and loss charts which are presented in this chapter (Figs. 21 to 29).

The variance from the trend is expressed in percent of the actual expense. For instance, the equation of the trend "cost of goods sold" for General Electric Co., as determined by the profit and loss chart shown in Figure 22 is:

$$\text{Cost of goods sold} = -\$350\text{M} + 87\% \text{ of sales}$$

Applying this equation to the year 1955, for which sales were $3,-442,525, provides:

TABLE XX

A STUDY OF ACTUAL *vs.* TREND-DETERMINED COST

Name of Company (1)	Trend (2)	Variance (in percent of actual expense) 1950 (3)	1951 (4)	1952 (5)	1953 (6)	1954 (7)	1955 (8)
Pet Milk Company	Total expense = −\$500,000 + 98.8% sales	−1.0	−0.2	−0.1	+0.1	−0.05	+0.2
General Electric Company	Total Operating exp. = −\$300M + 97% sales	−1.1	−1.7	−1.4	−1.8	+0.7	+1.5
	Cost of Goods Sold = −\$350M + 87% sales	+1.4	−0.1	+0.9	−0.2	+0.6	−0.8
Gillette Company	Operating Expense = \$4M + 65% sales	−4.6	−1.0	+4.1	+0.2	−1.7	+1.0
Lehigh Portland Company	Manufacturing expense = \$4M + 51% sales	−3.9	−0.2	+3.2	+3.0	+1.0	−0.3
U. S. Envelope Company	Total Expenses = \$1M + 91% sales	−3.7	−5.0	+0.5	−0.2	−0.2	−0.6
General Motors Corp.	Total Expenses = \$300M + 77% sales	−7.2	−1.1	−0.7	+4.5	+3.7	+0.04

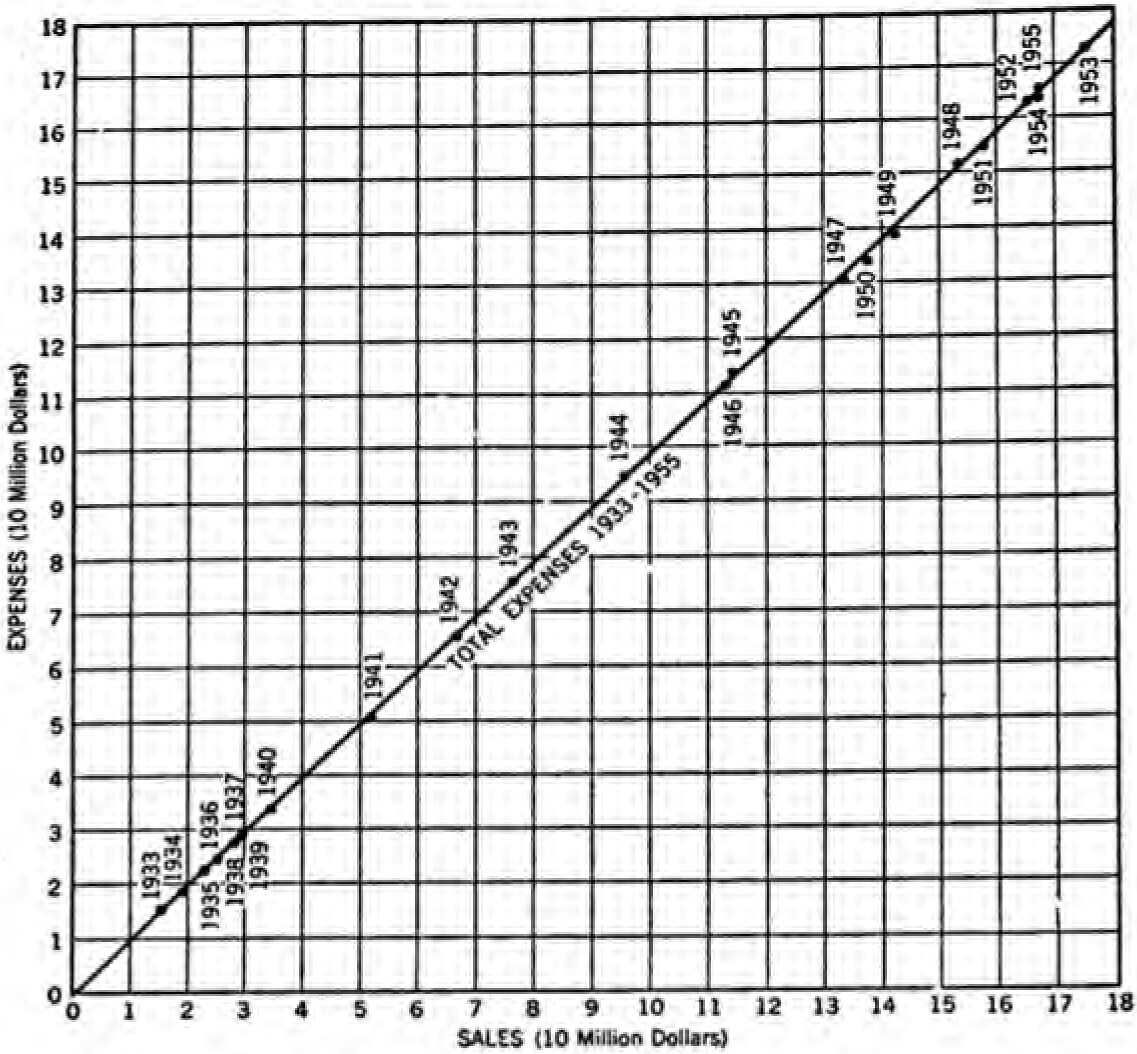

Figure 21. The Pet Milk Company Sales *vs.* Total Expenses

$$\text{Cost of goods sold (P. and L. Chart)} = -\$350\text{M} + \frac{87}{100} \times 3{,}442{,}525$$
$$= \$2{,}645\text{M}$$

Actual cost of goods sold for the year 1955, as shown in Table XXII, was:

Cost of goods sold (actual) = \$2,666M

The difference of \$21M, expressed in percent of the actual expense is:

Variance in percent $= \frac{21}{2{,}666} = \frac{8}{10}$ of 1 percent as shown in Table XX, Col. 8.

A variance of 8/10 of one percent is truly negligible. Although opinions vary greatly in the matter, it can be said that a variance of up to 2 percent should be considered as acceptable for the purpose

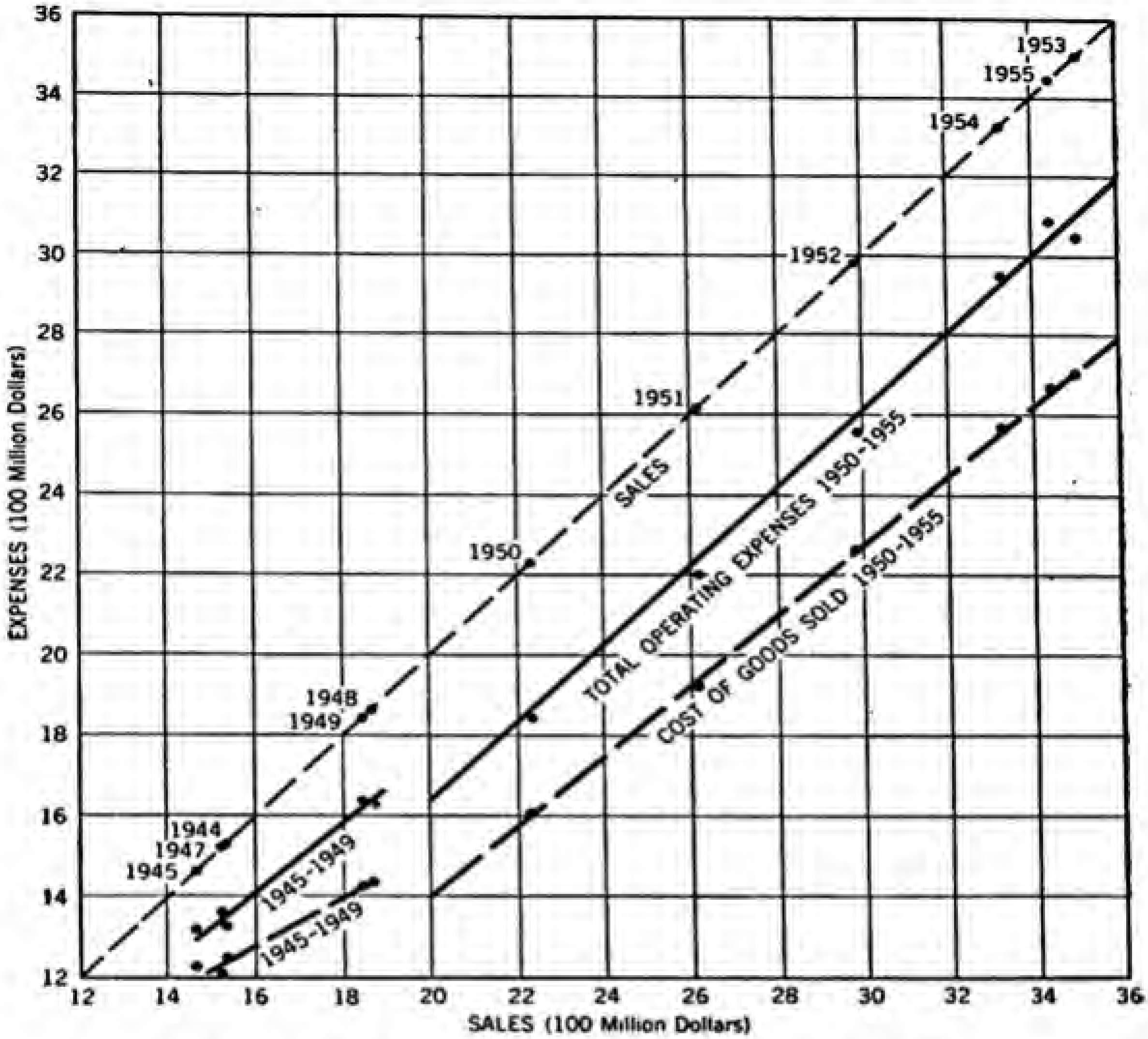

Figure 22. General Electric Company, 1945–1955

of the managerial control of costs. Table XX shows that 80 percent of the samples provided (34 for a total of 42) resulted in a variance of less than 2 percent. It should, of course, be noted that the scope of this study is too limited to qualify Table XX as a test of the profit and loss chart as a valid standard. It can be said, however, that the results shown are truly representative of what has been, over the years, the writer's experience when using profit and loss charts in industry for the purpose of profit control. The results shown in Table XX are also truly representative of extensive research work undertaken by the writer's students at Columbia University during the last ten years. It has been found that, as a rule, and regardless of changes in sales volume, prices, wages, material cost, etc., a variance of 2 percent or less is what can be expected in a well-managed business, as long as

there has been no fundamental change in the conditions of operation.

When, instead of being about 2 percent, the variance reaches 5 or 7 percent or more, this indicates, as a rule, a fundamental change in the conditions of operation of the business. A careful analysis of the situation is in order. In fact, it is one of the greatest advantages of the profit and loss chart that it does call attention to the fact that the actual situation departs from what can be, in a well-managed business, considered as a standard.

To provide a satisfactory explanation of a substantial variance generally requires access to data which, as a rule, are not available to outsiders. Sometimes, however, the analysis of the situation may result from the reading of annual reports to the stockholders or from giving consideration to well-known circumstances.

In general, the war period from 1941 to 1944 and the reconversion period following the war resulted in many departures from established trends and in some cases in fundamental changes in the sales expense pattern. This was particularly the case with the heavy metal industries. In food and clothing there were few changes in methods of manufacture.

The heavy Federal income tax on corporate profit which started with World War II has had such an impact in some cases that the postwar trend should be plotted before Federal income tax if one wants to get a picture that compares to the prewar pattern. In other words, the company in such a case has absorbed the tax burden (see, for instance, General Motors Corporation, Figs. 28 and 29). The same is not true in other cases (see, for instance, Pet Milk Company, Fig. 21).

Some companies have been affected by the recession of 1949 and their cost-to-sales relationship for this year may be out of trend. The same is true in another direction for the companies whose market expanded suddenly at the time of the Korean War. Later on some companies which have taken advantage of the accelerated depreciation laws (see Chapter IX) have shown an increase in depreciation expense which may have put the years 1953 to 1955 slightly out of trend.

Changes in accounting methods may also affect the regularity of cost-to-sales relationship for a company which would otherwise show a well-established trend.

As a whole, however, it remains true that the well-managed and successful companies tend to show, over a period of years, a reasonably well-defined linear trend of relationship of cost to sales.

The following charts, prepared from the data of the published state-

ments of the corporations, are, and necessarily must be, given in terms of the accounting classifications of expenses which these companies use. Accordingly, the "profit and loss" shown in each case is the profit and loss *before* whatever other expenses that are not accounted for. In a number of cases the profit and loss trend *before Federal taxes* is given for the reason that such expenses are not under the control of the company and their inclusion distorts the picture of the inherent economic characteristics of the business. In some cases, there are shown only certain classes of expense in relation to sales, to illustrate the fact that in many cases the expenses of different levels (cost of manufacture of goods sold, for example) show specific trends over either short- or long-term periods.

We will examine the data of individual companies in different lines of endeavor and also of some whole industries.

A. INDIVIDUAL COMPANIES

1. The Pet Milk Company

Table XXI shows the record of this company for a twenty-three year period, from 1933 to 1955, as published in Moody's *Industrial Manual*. During this period, as sales varied from a low of \$15.6 million to a high of \$175.1 million, the company has been adding to its properties and enlarging its productive capacity. The rate of Federal income tax before and after the war has changed radically. Yet the trend of total expenses to sales has been consistent during this entire period. The *total expenses* include Federal income taxes, depreciation, and special reserves.

The total expenses, when plotted against sales, give the results shown in Figure 21. The trend of total expenses is found to be

$$\text{Average total expenses} = -\$500{,}000 + 98.8\%\ \text{sales}$$

This means that, *on the average* over this twenty-three year period, this company earned in net profits, after all charges, including Federal income taxes:

$$\text{Annual profit} = 1.2\%\ \text{sales} + \$500{,}000$$

Comparison with other milk companies. It is sometimes desirable to know how companies in the same industry compare with one another in the above particulars.

For instance, in this case, the above equation can be compared to that of the National Dairy Products Company, which, for the same

period of 1933-1955 is (on the basis of data published in Moody's *Industrial Manual*):

Average total expenses (including Federal income taxes) $= -\$10{,}000{,}000 + 98.5\%$ sales

TABLE XXI

PET MILK COMPANY

Year	Sales	Total Expenses (*including Federal income taxes*)	Profits Adjusted to Surplus
		(*Millions of Dollars*)	
1933	15.6	15.2	.4
34	19.4	18.7	.6
35	23.0	22.3	.7
36	25.1	24.1	.9
37	29.7	29.0	.6
38	28.5	27.6	.9
39	29.7	28.5	1.1
40	34.9	33.6	1.2
41	52.0	50.5	1.4
42	66.7	65.2	1.4
43	76.3	75.1	1.2
44	95.8	94.8	1.0
45	114.7	113.3	1.4
46	113.3	111.6	1.7
47	133.1	130.4	2.7
48	153.5	151.1	2.4
49	142.1	138.9	3.2
50	137.5	134.0	3.5
51	157.8	155.0	2.8
52	165.2	162.9	2.3
53	175.1	172.3	2.8
54	167.2	164.6	2.6
55	167.4	165.1	2.3

This comparison indicates a similarity of pattern, in spite of the fact that the two companies are of different size. In 1955, National Dairy Products sales reached \$1,260,200, almost eight times as much as the Pet Milk Company.

Over the twenty year period, 1933-1955, the actual annual expenses of the National Dairy Products have been within a short range of the average indicated by the above equation, with the only exception of the years 1954 and 1955 which, as indicated in the annual report issued

by the company, have been affected by some exceptional adjustments related to taxes among other matters (see Moody's *Industrial Manual*).

2. *General Electric Company*

The record of the company for the years 1944 to 1955 for annual sales, cost of goods sold, and selling, general, and administrative expenses is shown in Table XXII (as published in Moody's *Industrials*).

TABLE XXII

GENERAL ELECTRIC COMPANY

Year	Sales	Cost of Goods Sold	Selling, General, and Administrative Expenses
		(Millions of Dollars)	
1944	1,533	1,245	82
45	1,466	1,223	94
46	911	776	119
47	1,525	1,202	154
48	1,864	1,432	200
49	1,850	1,426	210
50	2,232	1,605	236
51	2,618	1,924	277
52	2,987	2,265	294
53	3,506	2,693	350
54	3,329	2,568	377
55	3,442	2,666	418

These data are plotted in Figure 22 for cost of goods sold and for total operating expenses (cost of goods sold, selling, general, and administrative expenses).

It appears that the twelve years 1944 to 1955 should be considered as two periods of six years each.

The first period (1944–1949) appears as one of readjustment. The year 1946 is not even shown because the sales were reduced to \$911,000,000 and their plotting is beyond the range of the chart. The other years of this period do not follow a well-established trend. This by itself is often characteristic of a difficult time.

The opposite is true for the *following six year period (1950-1955)* which is one of orderly expansion as indicated by a well-established trend of the relationship of cost to sales.

The equation of the trend of cost of goods sold for this period is:

$$\text{Cost of goods sold} = -\$350\text{M} + 87\%\ \text{sales}$$

The equation of the trend of total operating expenses is:

Total operating expenses = —\$320M + 95% sales

The area between the two trends represents the selling, general, and administrative expenses.

3. *The Gillette Company*

From 1936 to 1955, the sales and operating expenses of this company were as presented in Table XXIII (*Source:* Moody's *Industrial Manual*).

TABLE XXIII

THE GILLETTE COMPANY

Year	Net Sales	Total Operating Expenses
	(Millions of Dollars)	
1936	17.2	11.1
37	17.9	12.0
38	15.8	11.3
39	18.0	12.1
40	19.3	13.3
41	22.8	15.0
42	24.4	14.9
43	27.6	16.7
44	33.4	20.5
45	37.8	23.3
46	51.7	31.7
47	59.5	39.6
48	85.8	59.6
49	90.8	63.9
50	99.3	65.4
51	102.7	70.0
52	120.4	85.8
53	140.8	95.7
54	162.2	107.5
55	176.9	120.6

The data are plotted in Figure 23, which clearly shows that these twenty years should be considered as two distinct periods:

1. *From 1936 to 1946*, the cost-to-sales relationship followed the trend defined by the equation:

Operating expenses = \$2,000,000 + 58% sales

2. *From 1948 to 1955,* the trend is defined by

Operating expenses = \$4,000,000 + 65% sales

The year 1947 was obviously one of transition between the two periods.

The dotted lines in Figure 23 show how the trends, 1936–1946 and

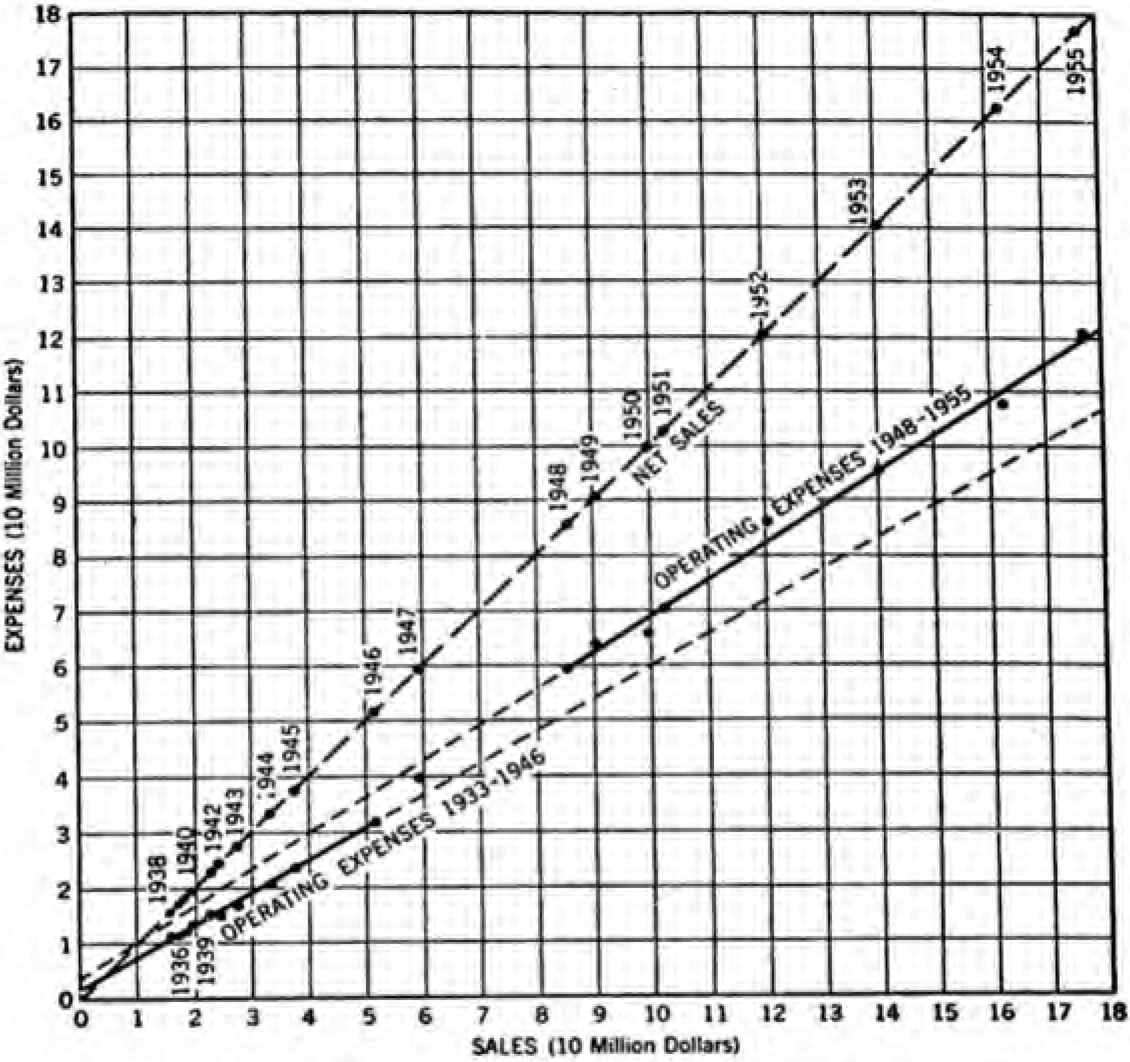

Figure 23. The Gillette Company, 1933–1955

1948–1955, compare to each other. The latter trend indicates more onerous conditions of operation. This reflects the cost of additional investments and additional operating expenses, including additional promotional and marketing expenses, which are to be expected when a company expands its sales, as the Gillette Company did, from \$17.2 million in 1936 to \$176.9 million in 1955.

The percentage of *operating profit per dollar of sales* which was 35.4

percent in 1936 was *reduced* to 31.8 percent in 1955. This, however, should be considered in the light of the fact that the actual profit, which was $6.1 million in 1936 increased to $56.3 million in 1955, and that this meant an *increase of the percentage of net income to net worth* from 21.2 percent in 1936 to 42.8 percent in 1955 (analysis published in Moody's *Industrial Manual*).

4. The Dow Chemical Company

The operations of this company for the years 1938 to 1947 are reported in Moody's *Industrials* as in Table XXIV.

TABLE XXIV

DOW CHEMICAL COMPANY

Year	Sales	Cost of Goods Sold	Total Operating Expenses
		(Millions of Dollars)	
1938	21.71	15.83	17.34
39	23.45	16.84	18.70
40	37.74	27.35	30.17
41	46.91	33.18	36.87
42	78.38	56.43	60.27
43	105.43	76.96	81.43
44	120.43	94.62	100.48
45	124.57	95.52	102.44
46	101.81	85.04	93.05
47	130.43	——	110.59

These data are plotted in Figure 24, from which it will be noted that both the cost of goods sold and the total operating expenses follow very definite straight-line trends in relation to sales for the period from 1938 to 1943. After 1943, during the war period and after the war, both the cost of goods sold and the total operating expenses in relation to sales depart from their respective prior trends. While the chart shows that these expenses for the years 1944-1947 have increased *with respect to sales,* does this mean that these expenses have increased in relation to physical volume of output? It may or it may not. We have no information on unit selling prices and therefore can not answer the question.

If unit selling prices had been reduced, the effect shown in the chart may be accounted for. Or it may indicate both that selling prices had been reduced and that expenses per physical volume of output may have increased. Both causes may have been operating. This is a

good example of how expense points may lie outside of a prior trend, due to either price change or expense change or both. The real causes must be learned from more detailed reports of operations, which are not available in the usual published financial reports.

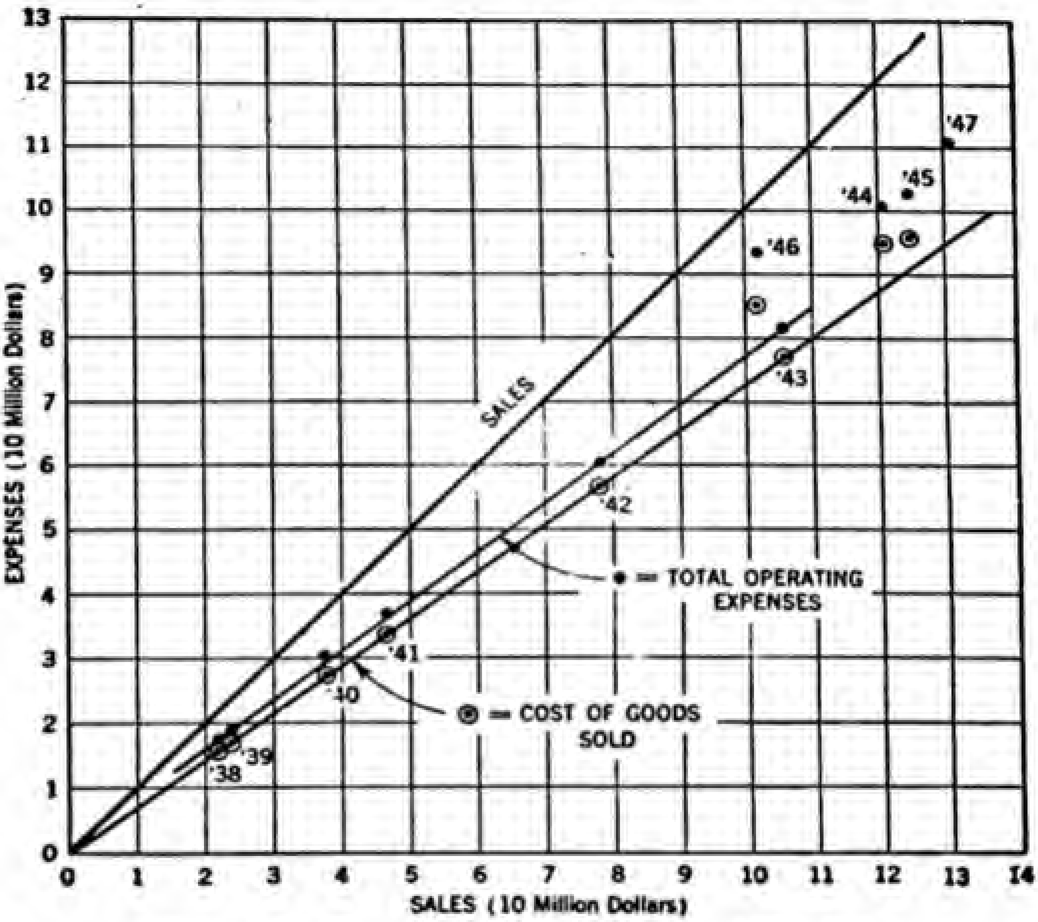

Figure 24. Dow Chemical Company, 1938–1947

5. The Monsanto Chemical Company and Subsidiary Companies

This company, in its 45th annual report to stockholders, issued in 1946, gives a record of its operations from 1937 to 1946, from which the particulars in Table XXV are taken.

These data are plotted in Figure 25, from which the following observations may be made. From 1937 to 1941, both the costs of goods sold and the expenses of operations follow a straight-line trend in relation to net sales. If this trend had continued for the next five years, the result would be as indicated by the continuing broken lines. Both gross profits and operating profits were greatly reduced ***relative to***

TABLE XXV

MONSANTO CHEMICAL COMPANY

Year	Net Sales	Cost of Goods Sold	Expense of* Operation
		(*Millions of Dollars*)	
1937	33.20	23.00	27.15
38	31.93	23.50	27.92
39	42.98	30.12	35.70
40	51.11	34.88	40.72
41	70.27	46.31	52.64
42	77.05	52.68	59.56
43	90.45	66.33	74.05
44	96.10	71.93	80.79
45	104.35	76.99	87.69
46	111.42	79.97	92.12

* Cost of goods sold plus selling, administration, and research expenses.

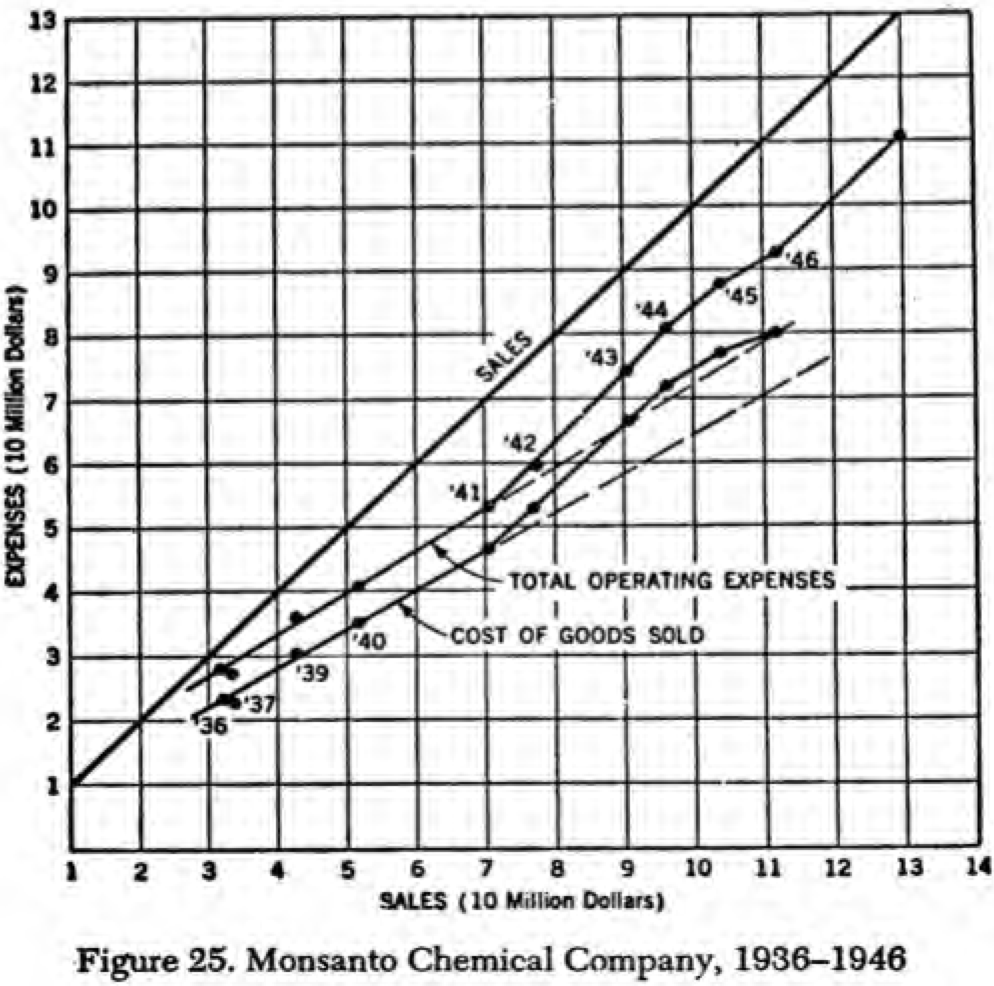

Figure 25. Monsanto Chemical Company, 1936–1946

net sales during the period from 1942 to 1946 as compared to the prior trend. The Dow Chemical Company, on the other hand, not only more than doubled its sales from 1941 to 1943, but it also maintained its profit trend in relation to sales of prior years. Both the Dow Chemical Company and the Monsanto Chemical Company experienced increased expenses in relation to sales during the period from 1944 to 1946.

6. *The Lehigh Portland Cement Company*

The report on this company is found in Moody's *Financial Manuals*, and for the years 1946 to 1955 the following results are recorded (Table XXVI).

TABLE XXVI

LEHIGH PORTLAND CEMENT COMPANY

Year	Net Sales	Manufacturing Expenses	Total Operating Expenses and Fixed Charges
		(Millions of Dollars)	
1946	25.83	16.31	21.00
47	30.40	19.48	24.69
48	38.37	23.56	27.09
49	40.99	24.62	30.73
50	44.31	25.50	32.16
51	50.76	29.31	36.30
52	53.61	32.39	40.44
53	58.54	34.93	45.64
54	59.71	34.81	45.64
55	70.89	40.00	52.01

Upon plotting the manufacturing expenses against net sales as shown in Figure 26, it is found that they fall along a consistent trend line (plain line in Fig. 26) during the whole ten year period under consideration. The equation of this trend is

$$\text{Manufacturing expenses} = \$4{,}000{,}000 + 51\%\ \text{sales}$$

The total operating expenses and fixed charges do not show the same linear regularity. They show a substantial range of variation from the general trend (dotted line). This indicates that the administrative-selling expense and fixed charges group was affected by some lack of regularity in relation to sales. A further analysis of accounting data and of the com-

pany's recent history would make it possible to relate this lack of regularity to market conditions and/or managerial decisions.

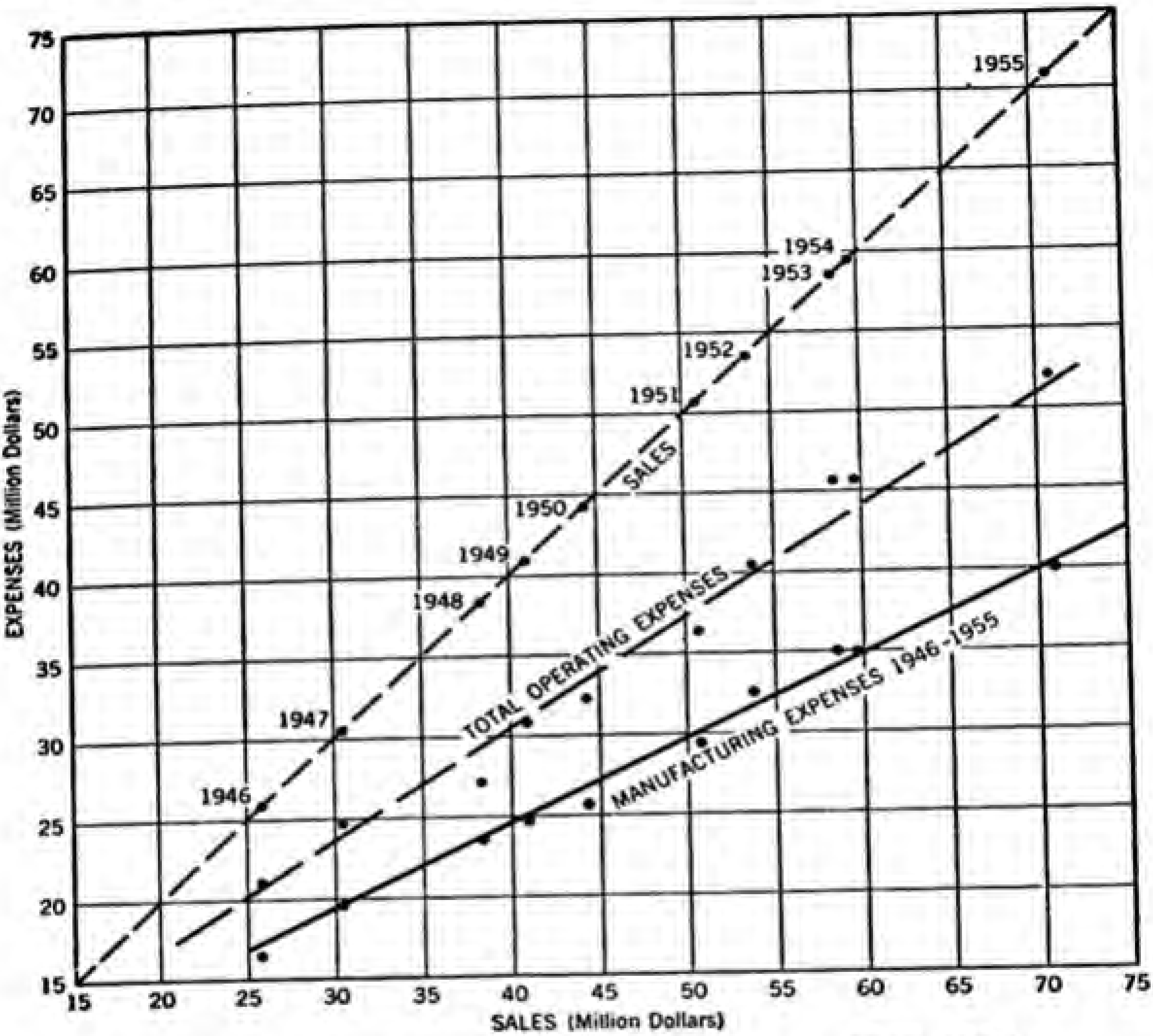

Figure 26. Lehigh Portland Cement Company, 1946–1955

7. *The United States Envelope Company*

This corporation is reported in Moody's *Financial Manual* as having the annual incomes and expenses for the years from 1947 to 1955 shown in Table XXVII.

The relation between net sales and total expenses is as plotted in Figure 27. Total expenses are found to follow a fairly definite trend as shown. The equation of this trend is:

$$\text{Total expenses} = \$1{,}000{,}000 + 91\% \text{ of net sales}$$

The years 1950 and 1951 are out of trend. The reason for this is given in the company's annual report to stockholders, which indicates that

TABLE XXVII

UNITED STATES ENVELOPE COMPANY

Year	Net Sales	Total Expenses
	(Millions of Dollars)	
1947	27.57	25.48
48	28.47	27.18
49	27.17	25.85
50	32.35	29.25
51	40.01	35.40
52	37.85	35.55
53	41.05	38.28
54	41.42	38.59
55	45.28	41.94

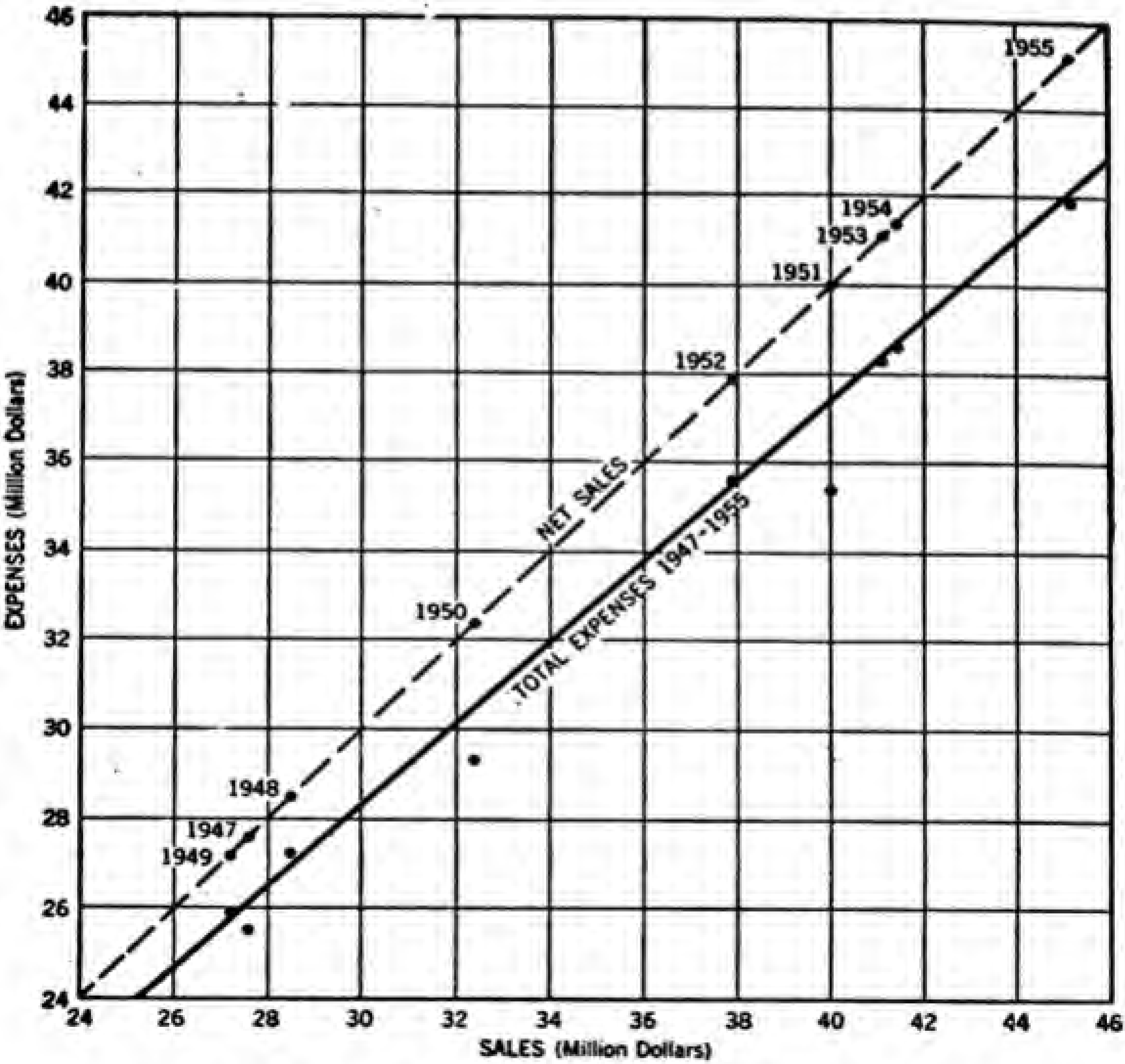

Figure 27. United States Envelope Company, 1947–1955

these two years were exceptionally profitable, due to a sudden increase in demand.

8. *The General Motors Corporation*

The operations of this company from 1922 to 1955 can be split in three distinct periods. (Data in Table XXVIII. *Source:* Moody's *Industrial Manual.*)

TABLE XXVIII

GENERAL MOTORS CORPORATION

Year	Net Sales	Total Operating Expenses
	(100 Millions of Dollars)	
1922	4.63	4.11
23	6.98	6.35
24	5.68	5.22
25	7.34	6.27
26	10.58	8.31
27	12.69	10.30
28	14.59	11.86
29	15.04	12.57
30	9.83	8.40
31	8.08	7.12
32	4.32	4.32
33	5.69	4.84
34	8.62	7.61
35	11.55	9.73
36	14.39	11.81
37	16.06	13.83
38	10.66	9.55
39	13.76	11.54
40	17.94	14.87
41	24.36	19.50
42	22.50	19.85
43	37.96	33.68
44	42.62	38.16
45	31.27	29.56
46	19.62	19.50
47	38.15	32.24
48	47.01	38.60
49	57.00	45.34
50	75.31	56.84
51	74.65	59.80
52	75.49	60.66
53	100.27	84.00
54	98.23	81.76
55	124.43	98.85

First period, from 1922 to 1935, the trend was as shown in Figure 28. Its equation is:

$$\text{Total operating expenses} = \$60{,}000{,}000 + 78\% \text{ of sales}$$

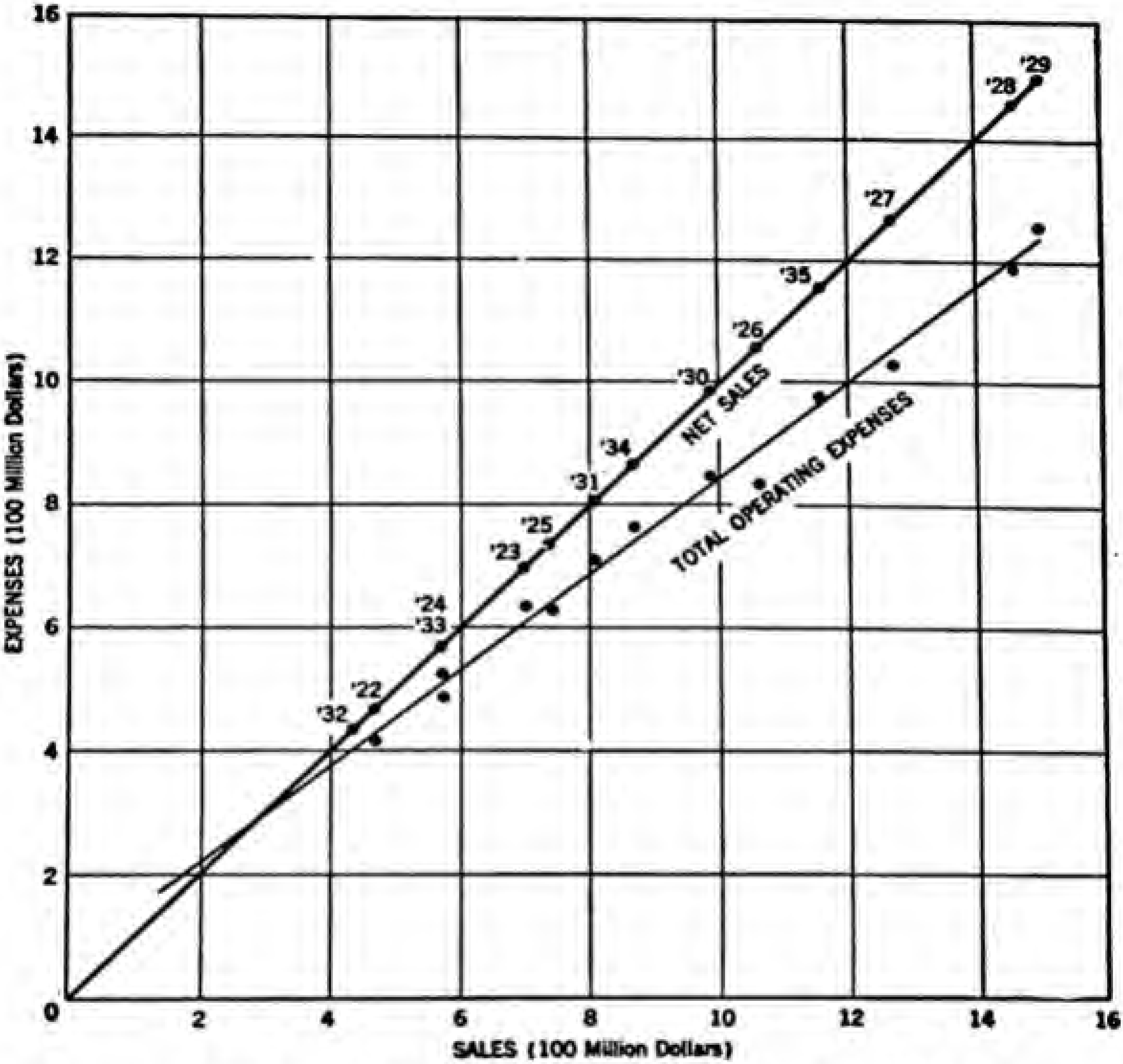

Figure 28. General Motors Corporation, 1922–1935

Second period, before, during, and after World War II, there is no well-established trend.

Third period, from 1946 to 1955, the trend was as shown in Figure 29. Its equation is:

$$\text{Total operating expenses} = \$300{,}000{,}000 + 77\% \text{ of sales}$$

The similarity between the trend of the first period and the trend of the third period is such that the trend for the period 1946-1955 can

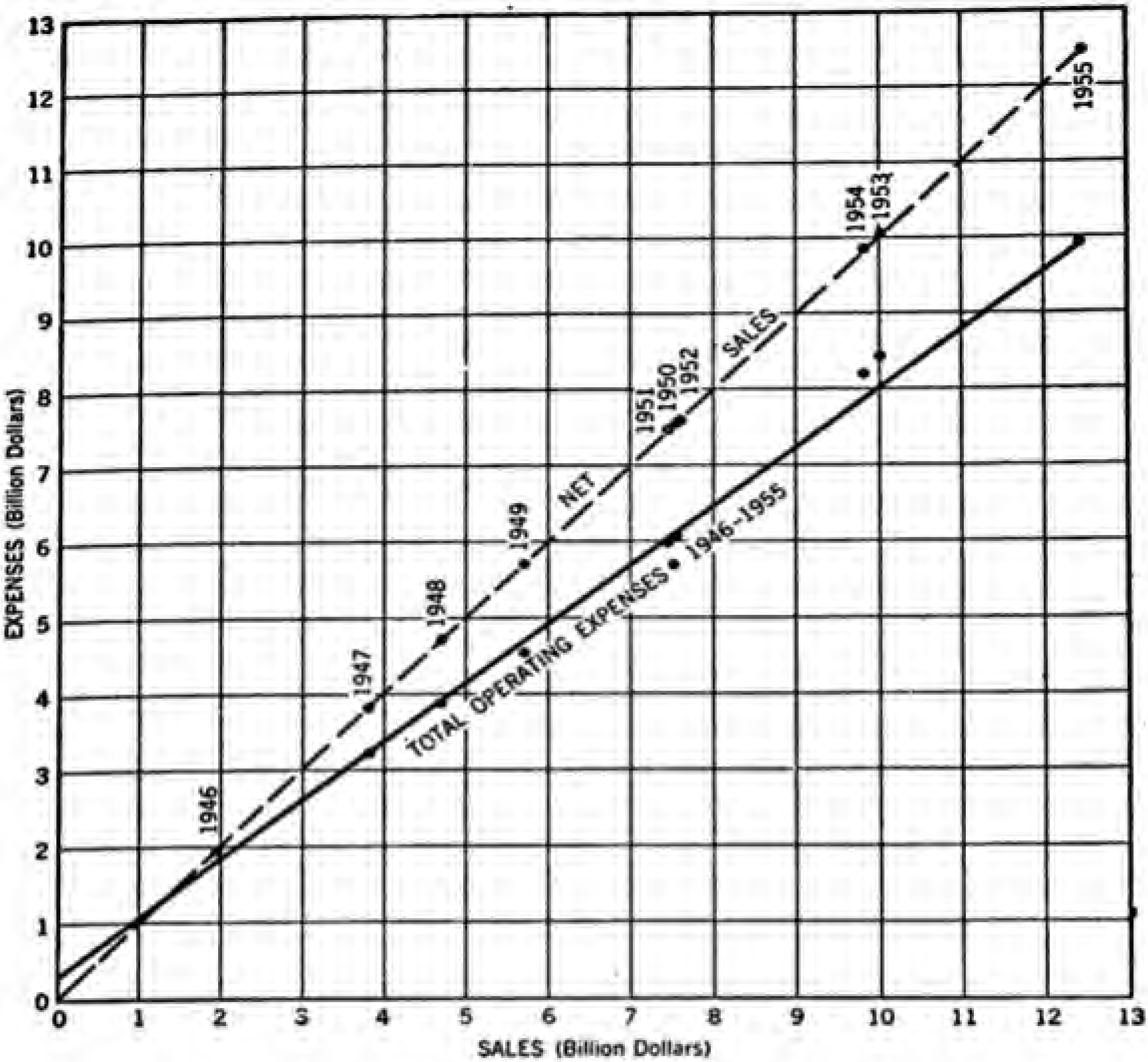

Figure 29. General Motors Corporation, 1946–1955

almost be considered as a return to the one for the period 1922–1935, especially if one considers the devaluation of the dollar, which affected the $60,000,000 factor in the original equation (for a discussion of the dollar as an economic yardstick, see Chapter XIV). It is interesting to note that both equations represent the operating expense before Federal income taxes, but that the Federal income taxes actually affected mainly the period 1946-1955. In this case, the company fully absorbed the tax burden increase.

B. WHOLE INDUSTRIES

The data on operations of whole industries are being compiled by various agencies and commercial associations. The Federal Trade Commission and the Securities and Trade Commission in their quarterly

Industrial Financial Report Series publish data on the incomes and expenses of the industries of the United States. From these publications, and from other sources, we have prepared the following profit and loss charts of important industries.

1. *The Mining Industry*

The profit and loss chart for this industry for the years 1932 to 1946 is shown in Figure 30. The expenses plotted are before interest charges, and therefore the vertical distances between the sales line and the line of expense trend show for any year the estimated annual amounts available for interest and dividends.

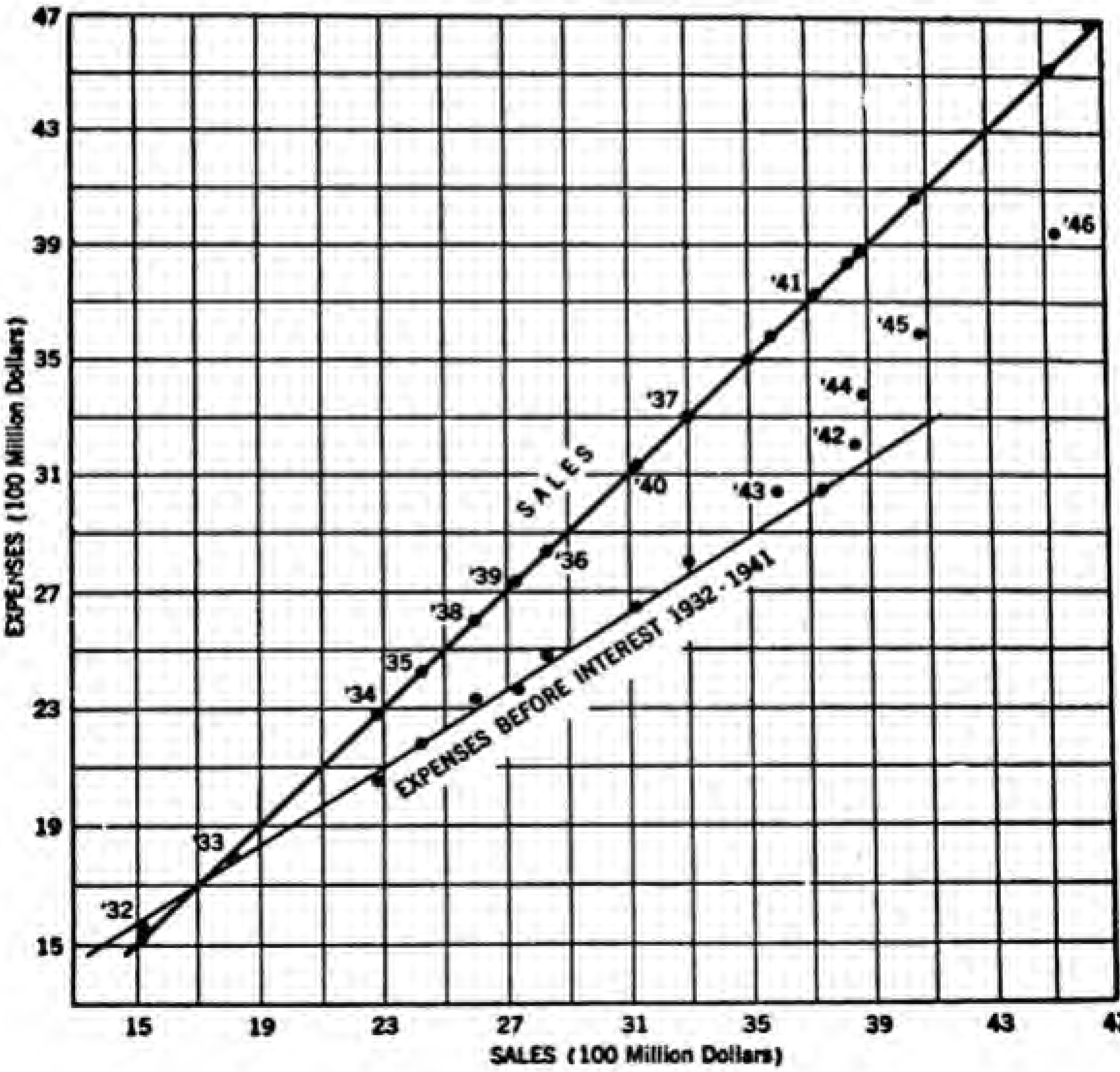

Figure 30. The Mining Industry in the United States, 1932–1946

The equation of the line of expense trend for 1932 to 1941 is

$$\text{Total expenses} = \$600{,}000{,}000 + 66\%\ \text{sales}$$

From this equation it follows that the annual sum available for disbursement to capital as dividends and interest for the years from 1932 to 1941 approximated

$$\text{Interest and profit} = 34\%\ \text{sales} - \$600{,}000{,}000$$

From 1942 to 1946, due to higher taxes and other causes, the industry did not follow the trend in expenses of the years 1932 to 1941.

The data from which the chart (Fig. 30) is constructed are as follows in Table XXIX.

TABLE XXIX

1. The Mining Industry

Year	Sales	Total Expenses before Interest	Profit and Interest
		(Millions of Dollars)	
1932	1,511	1,564	– 53
33	1 817	1,795	22
34	2,293	2,073	220
35	2,413	2,180	233
36	2,836	2 482	354
37	3,295	2,792	503
38	2,594	2,340	254
39	2,731	2,379	352
40	3,114	2 642	472
41	3,723	3,079	644
42	3,865	3,232	633
43	3,579	3,044	535
44	3,863	3,338	525
45	4,071	3,588	483
46	4,519	3,946	573

2. The Manufacturing Industries

The manufacturing industries expanded enormously in dollar value during and after the war period. In 1940, their annual sales were over 65 billions of dollars and in 1944 they were over 148 billions of dollars. In 1946 it was 125.9 billions of dollars. Interestingly enough, the trend of total expenses before excess profits and income taxes during

the war period did not depart very much from the expense trend during the peacetime years from 1933 to 1940.

In Figure 31 is shown the trend of expenses before excess profits and income taxes with sales for the years 1933 to 1940. The equation of this trend is

$$\text{Expenses} = \$3{,}600{,}000{,}000 + 87\%\ \text{sales}$$

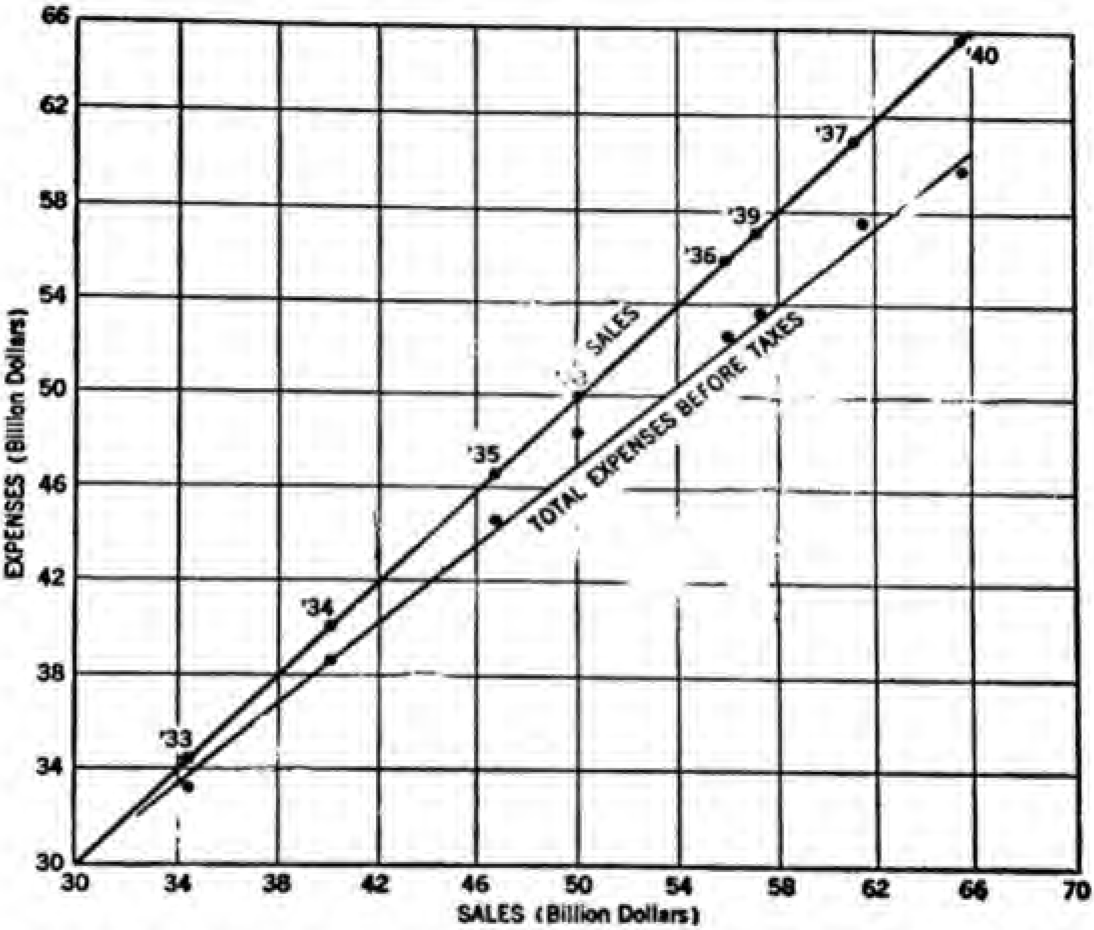

Figure 31. The Manufacturing Industries Expense Trend, 1933–1940

In Figure 32 is shown the relation of expenses before excess profits and income tax deductions to sales for the period from 1942 to 1946. The expenses are shown by the circled dots. For purposes of comparison, the expense trend for the period 1933 to 1940 is extended for this period, from which it is seen that the average of the years 1942 and 1943 is on the trend line while the expenses for the years 1944, 1945, and 1946 are slightly above the trend line.

The period 1947-1955 is plotted in Figure 33. As strange as it may

seem, the trend for this period is the same as the one determined for the period 1933-1940. It is defined by the same equation:

$$\text{Expenses} = \$3{,}600{,}000{,}000 + 87\%\ \text{sales}$$

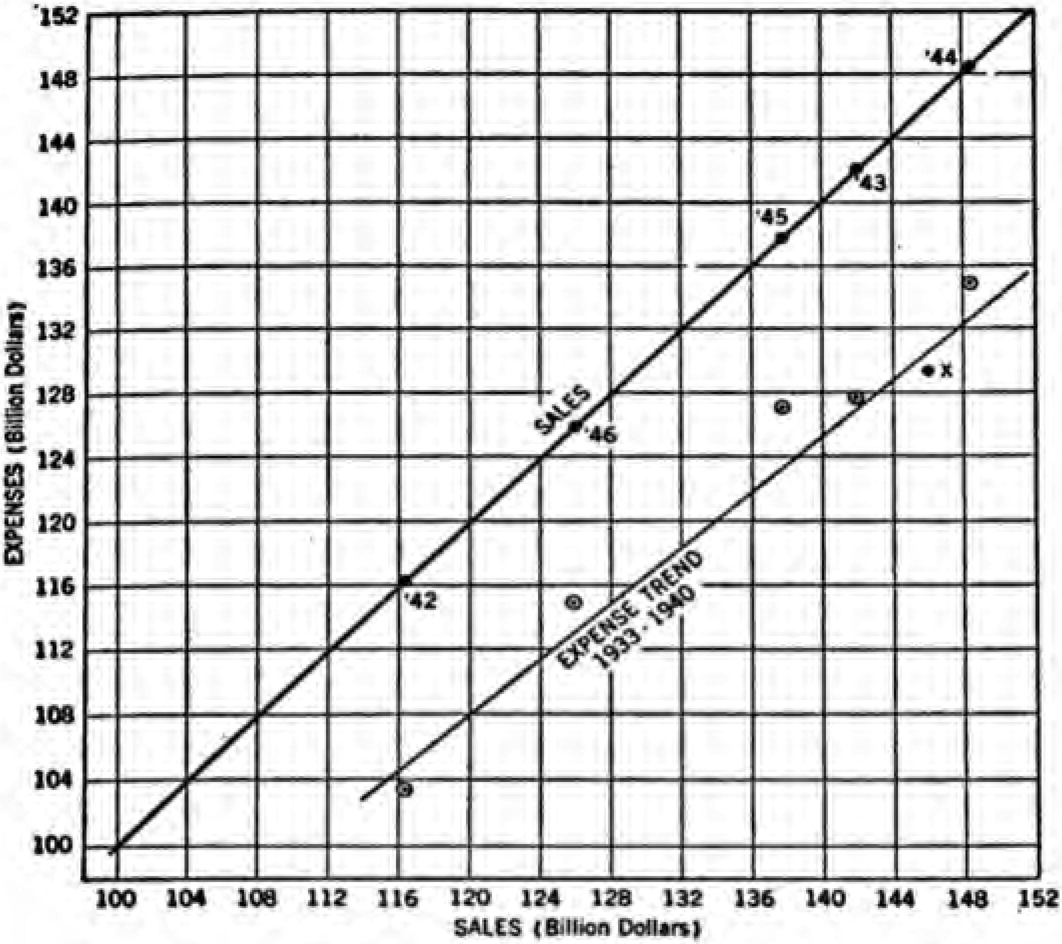

Figure 32. The Manufacturing Industries Expenses *vs.* Sales, United States, 1942–1946

Computing the variance, as was previously done for the data shown n Table XX, we find, for instance, that for the year 1955:

Billions of Dollars

Expenses (according to trend) $= \$3.6 + \frac{87}{100} \cdot 278.4$

$= \$246.8$

Expenses (actual) $= \$250.9$

Variance (in percent of actual expense) $= \frac{4.1}{250.9} = 1.6$

It was previously stated that a variance of less than 2 percent should be considered as negligible for the purpose of managerial control when studying the over-all picture of a business. This remark applies to the long-range trend of the manufacturing industries.

The data used in plotting Figures 31, 32, and 33 are as in Table XXX. (*Source:* Federal Trade Commission and Securities and Exchange Commission.)

TABLE XXX

MANUFACTURING INDUSTRIES

Year	Sales	Total Expenses after Interest before Income Taxes
	(Billions of Dollars)	
1933	34.3	33.4
34	40.1	38.7
35	46.7	44.5
36	55.9	52.3
37	61.4	57.7
38	50.0	48.4
39	57.1	53.4
40	65.7	60.1
41	92.0	80.8
42	116.2	103.5
43	142.0	127.7
44	148.5	134.8
45	137.8	127.1
46	125.9	115.0
47	150.7	134.3
48	165.6	147.3
49	154.9	140.5
50	181.9	159.3
51	212.2	186.9
52	250.2	227.7
53	265.9	241.9
54	248.5	228.0
55	278.4	250.7

3. The Electric Utility Industries

The Edison Electric Institute issues annually very complete detailed data on the revenues and expenses of the electric utility industries. Table XXXI shows the operating revenue, the expenses before

taxes (operating revenue deductions before taxes) for the years from 1933 to 1955.

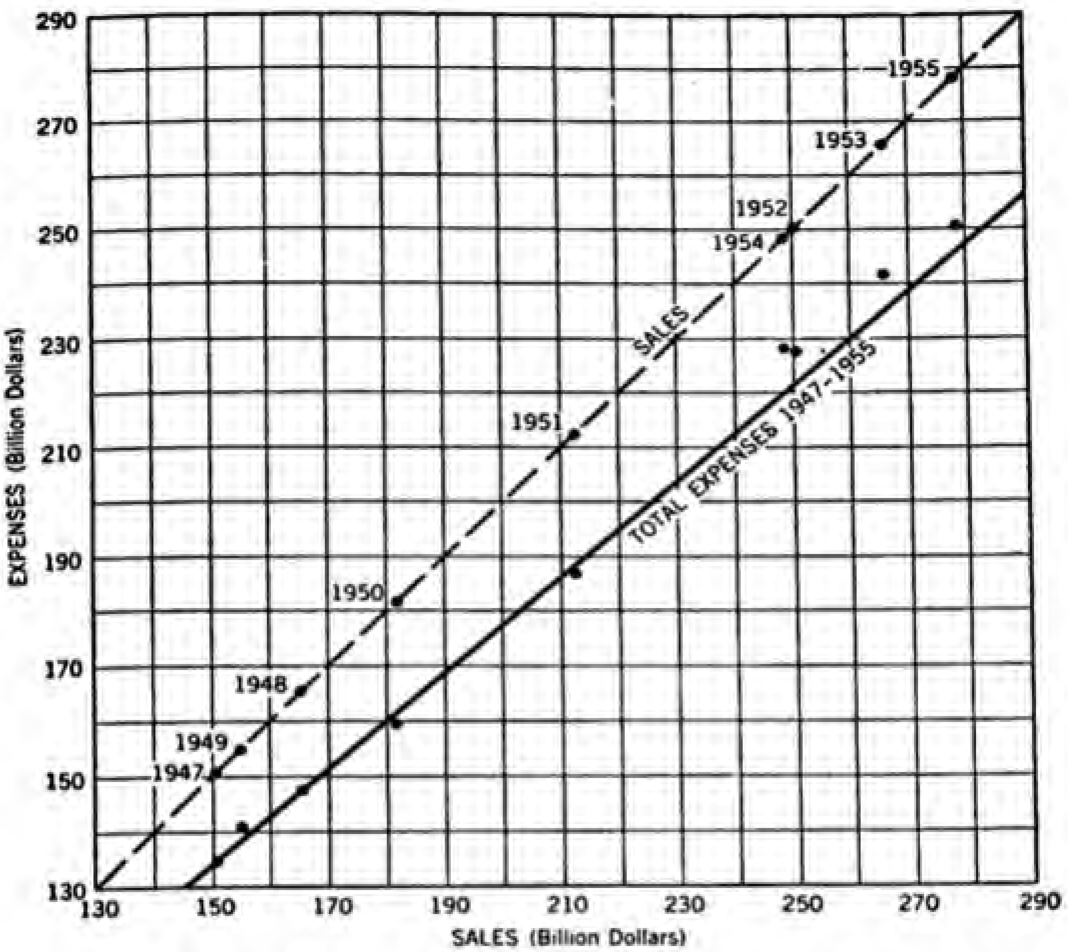

Figure 33. The Manufacturing Industries Expenses *vs.* Sales, United States, 1947–1955

The data for the period 1933-1946 are plotted in Figure 34, from which it will be noted that the operating expenses before taxes for the period from 1933 to 1943 followed a definite straight-line trend. The equation of this trend is

$$\text{Operating expense before taxes} = -\$150{,}000{,}000 + 56\%\ \text{sales}$$

The total expenses (after taxes) follow a straight-line trend from 1933 to 1940, after which date the Federal income and excess profits taxes become very much greater, bending the total expense line sharply upward.

TABLE XXXI

ELECTRIC UTILITY INDUSTRIES

Year	Operating Revenues	Operating Expenses before Taxes
	(Millions of Dollars)	
1933	1,640	766
34	1,710	812
35	1,785	853
36	1,911	918
37	2,031	997
38	2,018	988
39	2,148	1,047
40	2,277	1,123
41	2,467	1,226
42	2,609	1,305
43	2,816	1,434
44	2,955	1,544
45	3,012	1,581
46	3,121	1,718
47	3,480	2,040
48	3,886	2,383
49	4,113	2,419
50	4,510	2,596
51	5,005	2,875
52	5,426	3,090
53	5,940	3,366
54	6,317	3,514
55	6,930	3,775

Figure 35 shows the trend for the period 1947-1955, which follows a definite straight line. The equation of this trend is:

$$\text{Operating expense before taxes} = \$350{,}000{,}000 + 50\%\ \text{sales}$$

This trend is shown as a plain line. The broken line, marked "1933–46 trend" shows how the two compare with each other. It will be noted that the year 1955 is between the two trends.

II. BREAK-EVEN CHARTS

As stated previously, the break-even chart is derived from the confidential data of a company and cannot be constructed from the data of a company's published statements. Such confidential data are made available to us in our professional practice but we cannot use them without

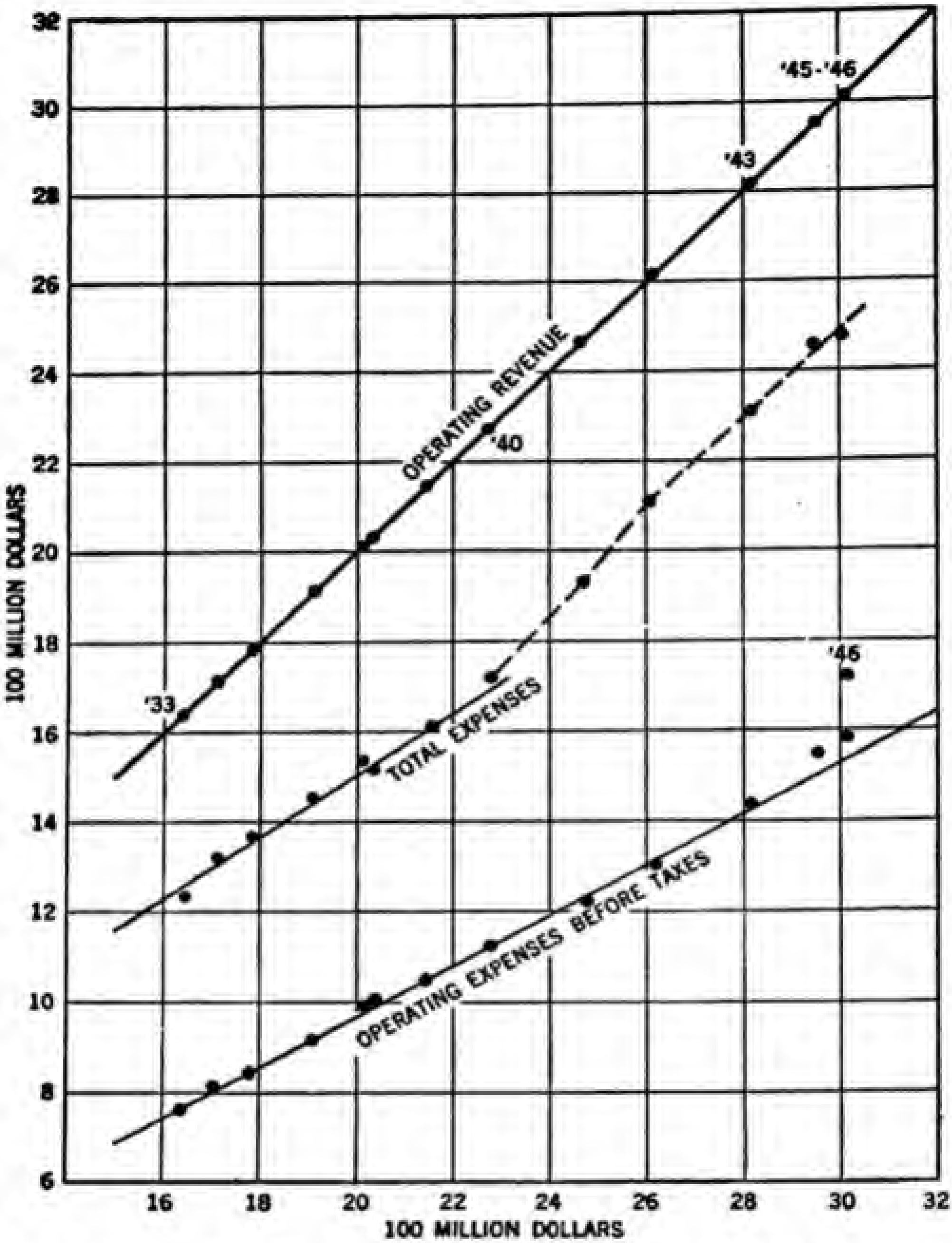

Figure 34. Electric Utility Companies, 1933–1946

the permission of the company, and then only without stating the source of the data. A well-known company, which we will designate The XYZ Company, has let us use its data for the following illustration of the relation between the several annual break-even charts of the company and the profit and loss chart of the company over the same period. The case of The XYZ Company was reported by the writers in *Fortune* magazine, February, 1949.

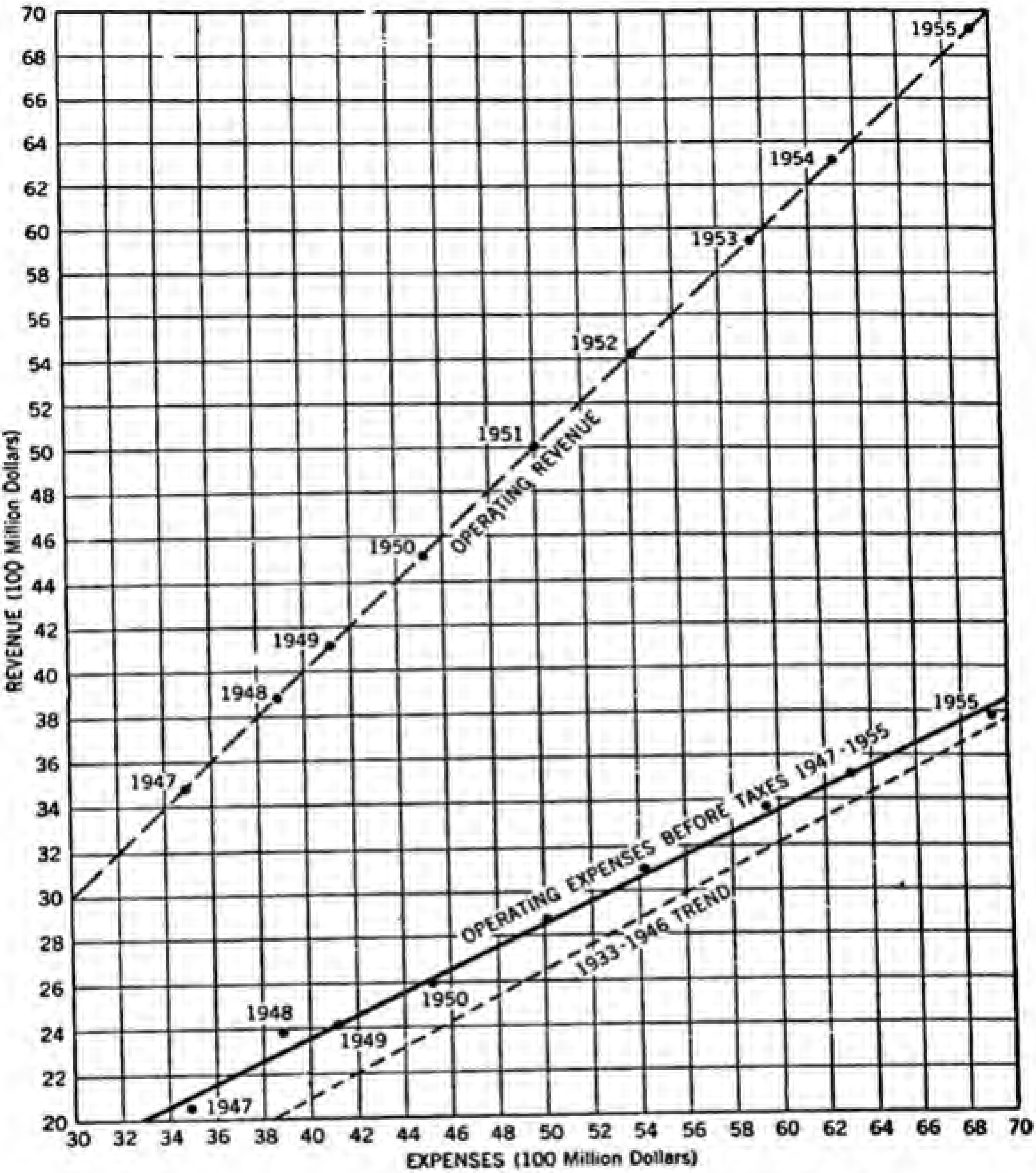

Figure 35. Electric Utility Companies, 1947–1955

This company, for many years, has followed the practice of computing its break-even point each year by the usual laborious accounting procedure. This requires each year the service of three or four computers working many hours. The following table gives the results of their computations of the break-even points for the years 1938 to 1947. The graphic method, when applied as illustrated in Figure 36 for the year 1938, gave the break-even point as well as a clear picture

of the whole trend of expenses with sales in a very few minutes. The graphic method has now been adopted by this company.

The data computed by the company were as in Table XXXII.

TABLE XXXII

THE XYZ COMPANY

Net Sales and Expenses
1938–1947

Year	Break-Even Point *	Net Sales to Trade	*Operating Expenses and Cost of Goods Sold*		
			Total	Constant	Variable
1938	$12,913,911	$15,226,066	$14,019,590	$ 6,738,608	$ 7,280,982
39	13,960,717	17,130,619	15,517,845	7,103,074	8,414,771
40	14,603,717	18,460,978	16,517,463	7,358,083	9,159,380
41	16,172,047	21,265,247	18,720,357	8,081,010	10,639,347
42	19,732,569	29,900,347	25,184,698	9,151,768	16,032,930
43	22,638,923	36,905,230	30,841,545	9,622,221	21,219,324
44	28,418,513	40,965,311	35,565,101	12,231,044	23,334,057
45	27,182,197	44,871,999	35,732,036	14,044,769	21,687,267
46	32,948,713	44,697,252	38,681,441	16,871,059	21,810,382
47	38,396,129	49,120,889	43,687,157	19,453,015	24,234,142

* Break-even point as computed by the company's accounting department.

A. THE BREAK-EVEN CHART OF THE XYZ COMPANY FOR THE YEAR 1938

The break-even chart of this company for the year 1938 was prepared as follows, as explained in Chapter IV. The base of the chart Figure 36 is laid out to the scale of each division representing one million dollars. The annual sales for that year were $15,226,066. The point A on the base represents the annual sales. At this point, erect a vertical line A-B meeting the 45-degree line drawn through the origin O. Upon the vertical A-B, locate the point C such that the distance A-C equals to scale the constant total expense of $6,738,608, and the point D such that C-D equals to scale the variable total expenses for the above annual sales. Construct a horizontal line C-E through C and then join E and D. Where the line E-D cuts the 45-degree line is the break-even point. This point is vertically above the reading $12,900,000 on the sales scale at the base. This compares to the computed break-even point $12,913,911, given in the above table. In practical operation the break-even point as found from the chart is quite adequate. The chart in addition to locating the break-even point in a few minutes also shows the profit which should be realized and also the

variation of profit with sales. The break-even points for the years 1939 to 1947, as shown in Figure 37 when compared to those computed by the company are found in agreement.

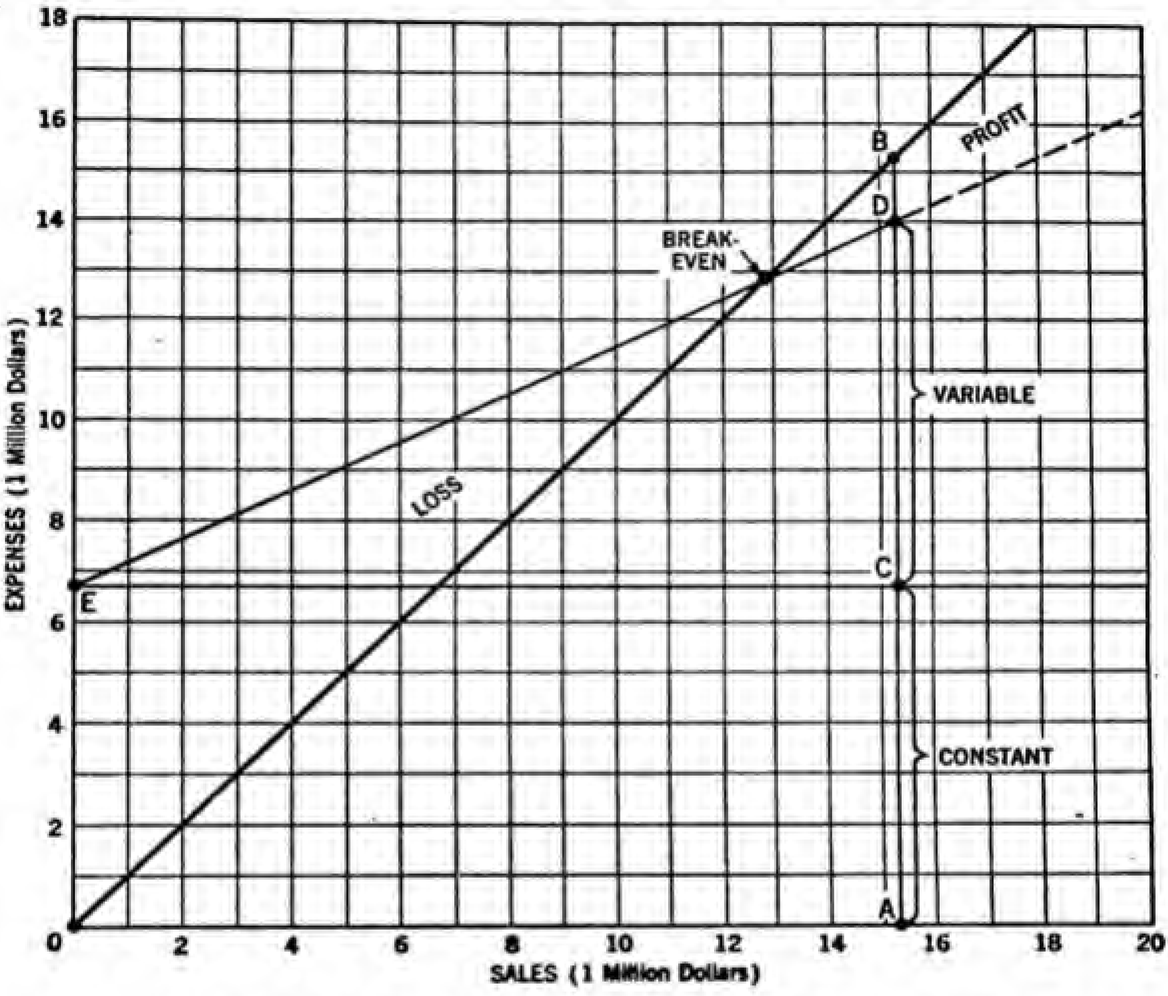

Figure 36. The XYZ Company Break-even Chart, 1938

B. THE SUCCESSIVE BREAK-EVEN CHARTS OF THE XYZ COMPANY FOR THE YEARS 1938–1947

It will be noted in the above table that The XYZ Company increased its sales from 15 millions of dollars to 49 millions of dollars during the period from 1938 to 1947. During this period of years the company gradually increased its constant total expenses. Its variable total expenses naturally increased each year with increasing sales. However, the relation of its variable expenses to total sales did not remain fixed as Table XXXIII shows.

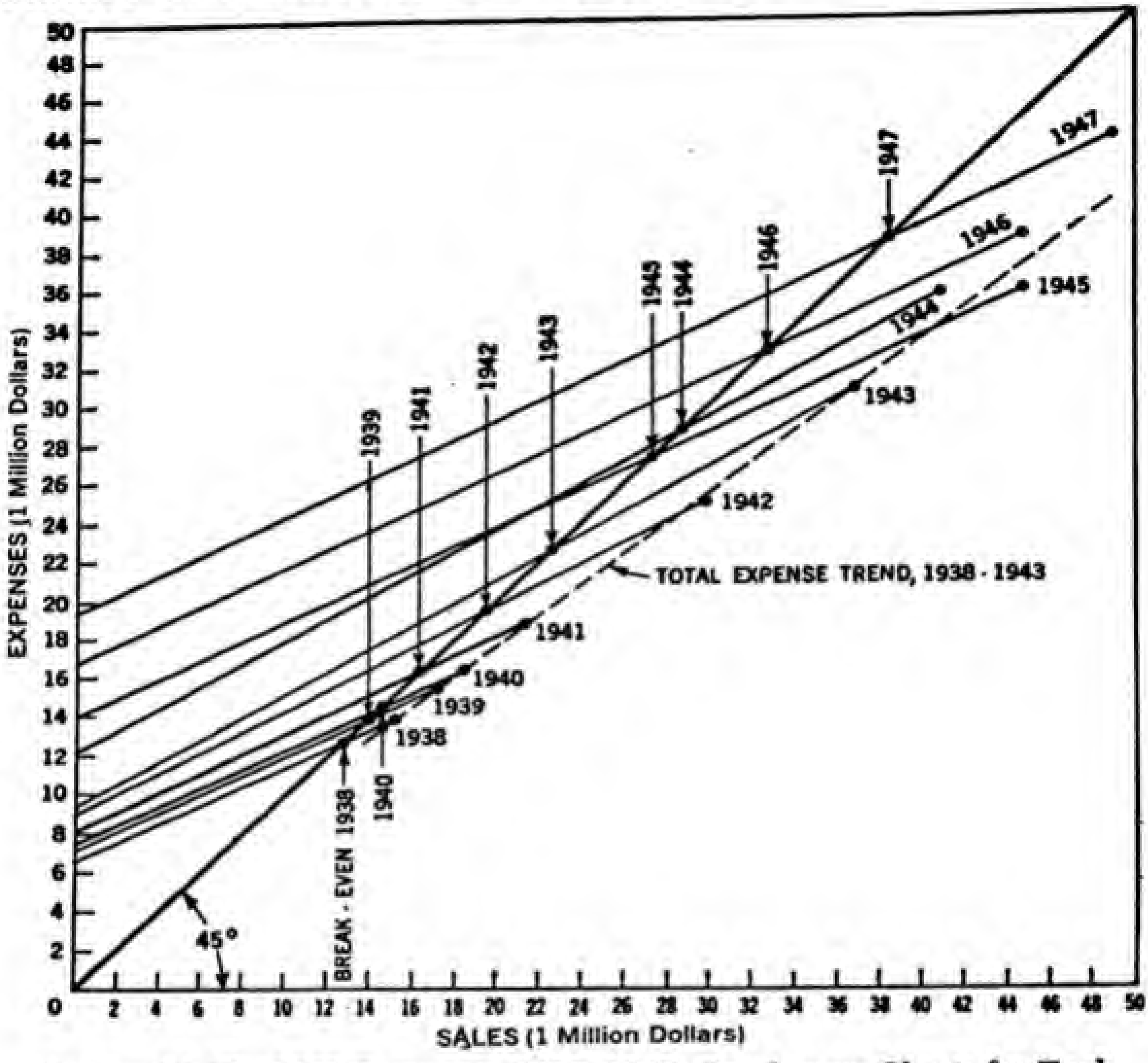

Figure 37. The XYZ Company, 1938–1947: Break-even Charts for Each Year and Profit and Loss Chart for the Period, 1938–1943

TABLE XXXIII

THE XYZ COMPANY

Ratio of "Variable Total Expenses" to Annual Sales

Year	Percent
1938	47.8
39	49.1
40	49.6
41	50.0
42	53.6
43	57.5
44	56.9
45	48.3
46	48.6
47	49.2

If the break-even charts for all the years from 1938 to 1947 are plotted on the same chart, the results as shown in Figure 37 are obtained. Here we find not only the break-even points of each year clearly shown, but also how the constant total costs have increased year by year and how the variable costs have changed from year to year.

This composite chart clearly reveals the changes in the "economic characteristics" which the company has experienced for a period of 10 years. With the year 1944 there was a decided increase in the constant total expenses with only a slight reduction of the variable expense ratio. Accordingly, with the increase in sales not compensating for the increase in the constant total expenses, the profit was out of trend. In 1945, however, even though there was an additional constant total expense, the ratio of the variable expenses was substantially reduced so that in view of greater sales a greater profit was realized than indicated by the earlier trend. While the variable expense ratio after 1945 was held at a favorable low level, the company at the same time continued each year to increase its constant total expenses. Since the annual sales after 1945 did not increase in sufficient proportions to balance the increases in constant total expenses, the profits of the company for the years 1946 and 1947 were much less than indicated by the earlier trend from 1938 to 1943, and at the same time the break-even point went even higher. Thus the company is found in its later years in a more vulnerable position.

C. THE PROFIT AND LOSS CHART OF THE XYZ COMPANY

Figure 35 also shows the trends of profits with sales for The XYZ Company for the years 1938-1947. While during the period from 1938 to 1943 the company increased its constant total expenses each year and changed its variable expense ratios to higher levels, its total expenses and its profits followed a consistent trend in relation to sales. The trend of total expenses for these years was \$220,000 + 77.5% sales. From 1944 to 1947, the total expenses and hence the profits departed markedly from this trend. Either volume of sales or selling prices or both were not in balance with the company's increasing overhead.

This chart clearly shows that as a company increases its overhead, its sales must be in balance with these increases if prior trends in profits are to be maintained. The XYZ Company had overexpanded its market. Actually, a few years later, through the process of a merger, it was absorbed by another company.

VI

APPLICATIONS—PROBLEMS OF INVESTMENT

THE PROFIT AND LOSS CHART, which provides a graphic record of the trend in expenses and profits as a function of sales over a period of years, and the Break-Even Chart, which reveals the current economic characteristics of a business with its potential relation of profit to sales, both provide convenient means to management for the scientific control of operations. The analyses provided in the foregoing chapters are adaptable to the forecasting and control of operations in a manner which is not inherent in the usual accounting procedures. A well-managed business does operate by the use of an expense budget based on anticipated sales. These budgeted items of expense are standards against which the actual expenses incurred are measured. But again such standards are based on a given anticipated monthly or annual sales. Budgets of expenses are sometimes prepared for several probable monthly or annual sales and are referred to as variable budgets. Budgets provide a necessary tool of management for the purpose of managerial control, of production

planning, and of cost reduction. They do not, however, give a comprehensive picture of the whole range of possible relationships of expenses to sales, nor are they adapted to answering readily the many problems of policy which daily occur in operating a business and which problems will be considered in this and the following chapter.

The break-even and profit and loss charts are useful in *analysis, forecasting,* and *control.* Each has its particular adaptabilities. Together they provide the tools for working with a wide range of operating problems. Problems of investment and their probable economic effects on earnings and problems of management of current expenses and their effect on the cost of production are the two main classes of problems in which these charts are particularly useful. This chapter deals with problems of investment, the following chapter with problems of management.

I. INVESTIGATION PRIOR TO FINANCING A BUSINESS

A. CURRENT OPERATIONS

Investment bankers, when approached by a corporation for the purpose of securing an underwriting of a stock or bond issue or other forms of financing, usually require the applicant to furnish them with a report on its properties and business by an independent consulting engineer. It has been the authors' experience that the analysis provided by the profit and loss chart and the break-even chart are of great help in gaining a better understanding of the situation of a given business for the special purpose of deciding whether or not such an underwriting can be recommended. The following analysis and break-even chart was made by one of the authors for a beet sugar company which desired to float a bond issue of \$1,500,000 to pay off its current indebtedness. The company owned three mills, located in two states, and contracted with the growers for the delivery of beets to designated loading stations along the railroads. The revenues and expenses were determined as follows:

The average sugar content of the beets was 14½ percent. Of this amount, only 85 percent could be extracted after allowing for a 6 percent shrinkage. One ton of beets was found to yield 100 pounds (5 percent) of dried pulp and 32 pounds (1.6 percent) of molasses. The selling prices of the products were as follows: Granulated sugar 6¢ per pound; molasses \$8 per ton; dried pulp \$30 per ton. The capacity at which the mills were operated was 200,000 tons of beets annually.

It may be noted that beet sugar mills run for a period of 3 to 4 months during the year, generally from the first of October to the first of February. They are idle during the remainder of the year, and the time is spent in making repairs and renewals. A skeleton crew is maintained during the idle period. The period of operation is known as the "campaign." The total annual revenue is determined as follows: the amount of sugar packed from one ton of beets is

$$2{,}000 \cdot 0.94 \cdot 0.85 \cdot 0.145 = 232 \text{ pounds}$$

The annual production of all products is:

$$232 \cdot 200{,}000 = 46{,}400{,}000 \text{ pounds of sugar}$$
$$200{,}000 \cdot 0.05 = 10{,}000 \text{ tons of dried pulp}$$
$$200{,}000 \cdot .016 = 3{,}200 \text{ tons of molasses}$$

The annual revenue is:

Sugar	46,400,000 · \$ 0.06 =	\$2,784,000
Molasses	3,200 · \$ 8.00 =	25,600
Dried pulp	10,000 · \$30.00 =	300,000
Total		\$3,109,600

The annual costs are as follows: Growers' cost is based on a contract with the farmers or growers which provides that they shall be paid 45 percent of the selling price of the sugar extracted from the beets they furnish, with a minimum guarantee of \$5.22 per ton for 14½ percent sugar content and 85 percent extraction. Since the percentage on selling price prevailed, the mill-owner paid the grower at the rate of 232 · \$0.06 · 0.45 or \$6.26 per ton. Therefore, the total cost of raw materials (beets) was 200,000 · \$6.26 or \$1,252,000. This clearly is a variable total cost.

The costs of operation * were as in Table XXXIV.

Interest charges, due on outstanding bonds to the amount of \$1,500,000 at 7 percent, were \$105,000 annually.

Summarizing these costs, we find that the constant total costs are:

Cost from operations	\$1,115,000
Cost from bond interest	105,000
Total	\$1,220,000

* Costs of operation in this example include some of the "costs to possess." See page 319.

TABLE XXXIV

CONSTANT TOTAL ANNUAL COSTS OF OPERATION

A Beet Sugar Company

Agriculture	$ 175,000
Depreciation of agricultural equipment	15,000
Maintenance and repair of mills	125,000
Depreciation of mills	125,000
Factory and administrative expense	675,000
Total	$1,115,000
Variable Total Annual Costs of Operation	
Freight and cartage	$ 231,750
Unloading	15,000
Packing	1,000
Total	$247,750

The variable total costs are:

Growers' costs (beets)	$1,252,000
Due to operations	247,750
Total	$1,499,750

These data are plotted in Figure 38.

The line A-A′, representing the total constant costs less bond interest, is drawn at a height to scale of $1,115,000 from the base.

The line A-C, representing the additional variable total costs, is drawn so that A′-C = $1,499,750. The line D-E is drawn parallel to A-C and at a distance of $105,000 above A-C. The reason why bond interest is thus separated from the constant total costs is to show when the business breaks even before bond interest is met.

The point F is located at the distance of $3,109,600 to scale above the base. Ordinates to the line O-F then represent the incomes at different annual amounts of tons of beets sliced. The broken line O-G represents the revenue from sugar only.

The completed chart shows the annual tonnage required to break even (B_1) before bond interest. It also shows that the success of the business is principally dependent on the recovery of and the market for the by-products, pulp and molasses.

The success of the business is also largely dependent on the quantity of beets which may be procured from the farmers, the sugar content of the beets, and the price per ton paid the farmers. With all these

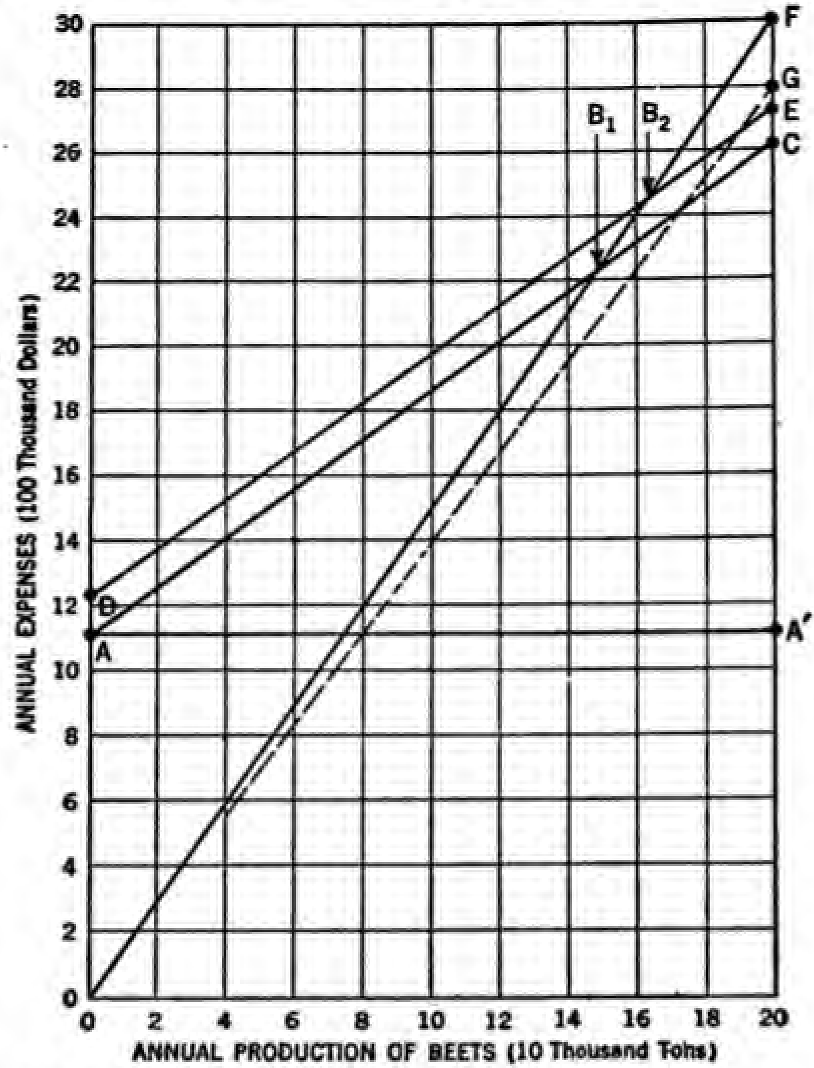

Figure 38. Break-even Chart for a Beet Sugar Mill

hazards the break-even point is high and the margin between success and failure is rather narrow, compared to other possible investment of funds.

B. PAST PERFORMANCE AS TO EARNINGS

One of the questions an investment banker needs to have answered, with reference to providing new funds for a business, is: How could the company have met the new fixed charges on the proposed issue of securities during the past several years of its history? This question may be answered by the use of the profit and loss chart *adjusted to account for borrowings* which would not have been required if the proposed financing had previously been in effect. This problem arises generally in the case of a company which, for some years, has been lacking in working capital and has financed its operations through

bank loans and factoring the sale of short-term notes and by other means. The additional risk capital which is to be provided through the sale of preferred stock or mortgage bonds incurs additional fixed charges on the business. These fixed charges, if the proposed risk capital had been provided earlier in its history, would have made it unnecessary for the company to borrow funds for working capital and hence any determination of how the company could have met these charges in the past requires the adjustment of its expenses in the past so as not to include the interest on its past borrowings. To illustrate how the profit and loss chart may be used to show the consequences of a new capital issue, the following case is used.

A certain company, call it the ABC Company, is capitalized by an issue of $10,000,000 of 6 percent cumulative preferred stock and $20,-

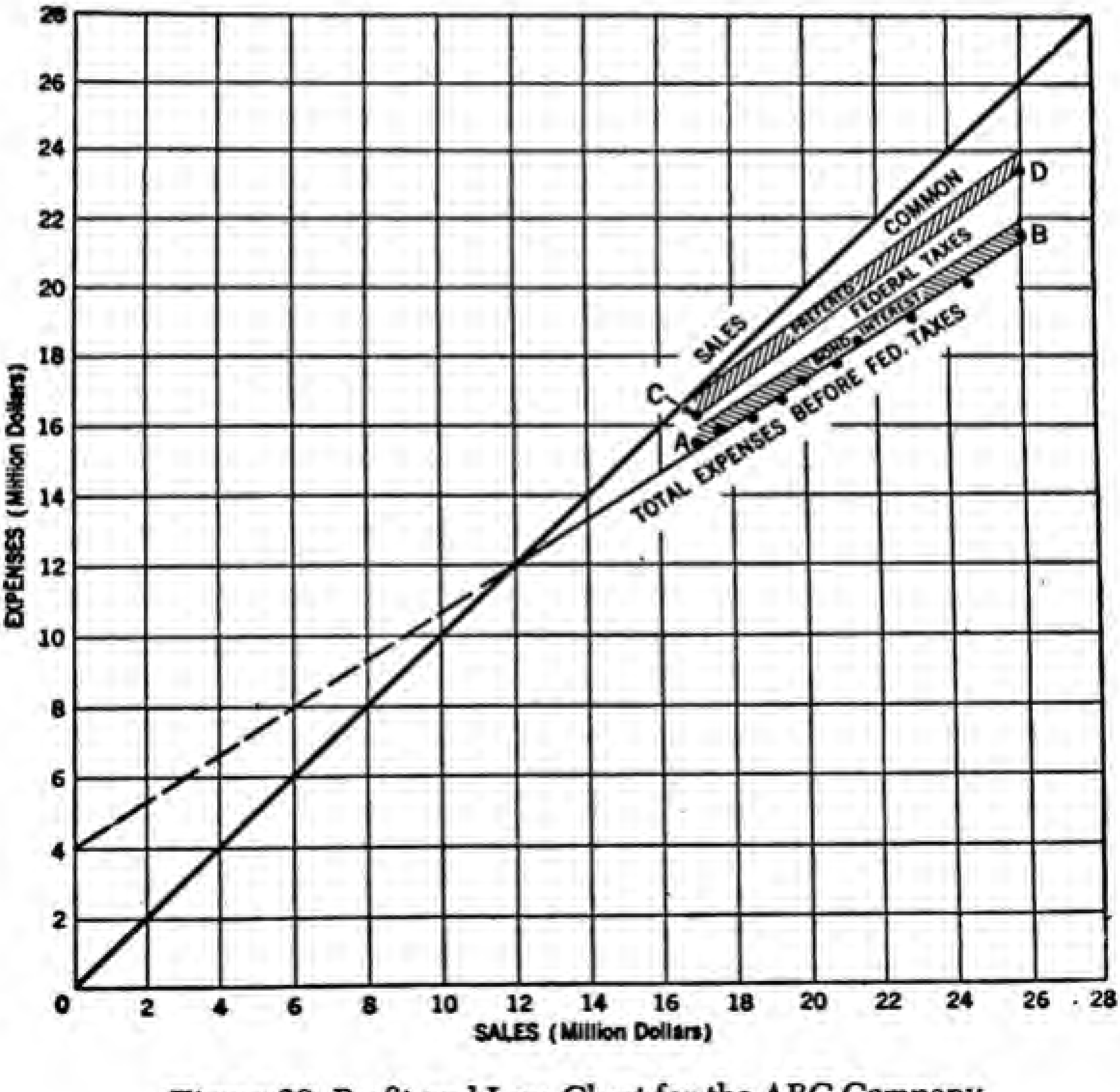

Figure 39. Profit and Loss Chart for the ABC Company

000,000 of common stock. Its capital is not sufficient to meet its needs and it proposes to issue \$10,000,000 of 6 percent mortgage bonds. The accountants prepare a statement of annual sales and total expenses less interest charges on borrowings for the past 10 years. These are plotted in Figure 39 and the total expense trend A-B is determined as shown. The equation of the trend line is:

$$\text{Total expense} = \$4{,}000{,}000 + 66.6\%\ \text{sales}$$

The equation of average profit before Federal taxes, P, is:

$$P = 33.3\%\ \text{sales} - \$4{,}000{,}000$$

The minimum annual sales for the period under review were \$17,000,000, whereupon the corresponding profit would be 33.3 percent of \$17,000,000 – \$4,000,000 = \$1,660,000. The corporation, during that year, would have earned its bond interest 2.7 times. The maximum annual sales for the period were \$26,000,000, resulting in an average profit of 33.3 percent of \$26,000,000 – \$4,000,000 = \$4,660,000 which is 7.7 times the interest on the proposed bond issue. The profit and loss chart of Figure 39 shows very clearly the proportion of bond interest to profits before taxes for the entire period. The profit after bond interest is subject to Federal income taxes, and the effect of these taxes is shown by the line C-D. The profit margin above C-D is available for dividends. After the dividends on the preferred stock, shown by the shaded area, are accounted for, the remainder is available for dividends on the common stock. Since stock dividends are payable only on income after Federal taxes and after bond interest, the average total disbursements before dividends follow the trend of the line C-D, the equation of which is:

$$\$2{,}800{,}000 + 79\%\ \text{sales}$$

Accordingly, the equation of average profits after bond interest and Federal income taxes available for dividends is

$$21\%\ \text{of sales} - \$2{,}800{,}000$$

When, for example, the annual sales are \$26,000,000, the profits available for dividends are 21 percent of \$26,000,000 – \$2,800,000 = \$2,660,000 which is 4.4 times the preferred dividend requirements.

The profit and loss chart, when prepared as shown in Figure 39, shows at a glance how bond interest, Federal income taxes, preferred dividends, and earnings on the common stock were related to profits as sales varied over a wide range. In case the departure of annual

expenses from the trend is significant and the Federal income taxes vary irregularly with profits throughout the years, it is better practice to chart the actual data in each case with corresponding trend lines to show the averages over the years.

C. PROBABILITIES OF EARNINGS ON CURRENT OPERATIONS

While the past performance on earnings of a company is important to the investment banker from the standpoint of providing a proven record to support the sale of a new issue of securities of a company, it is also important to review the current budget of operations of a company to learn the probabilities of meeting current commitments as to present fixed charges and of earnings on present stock issues. The current break-even chart of a company is useful for this purpose, as the following case illustrates.

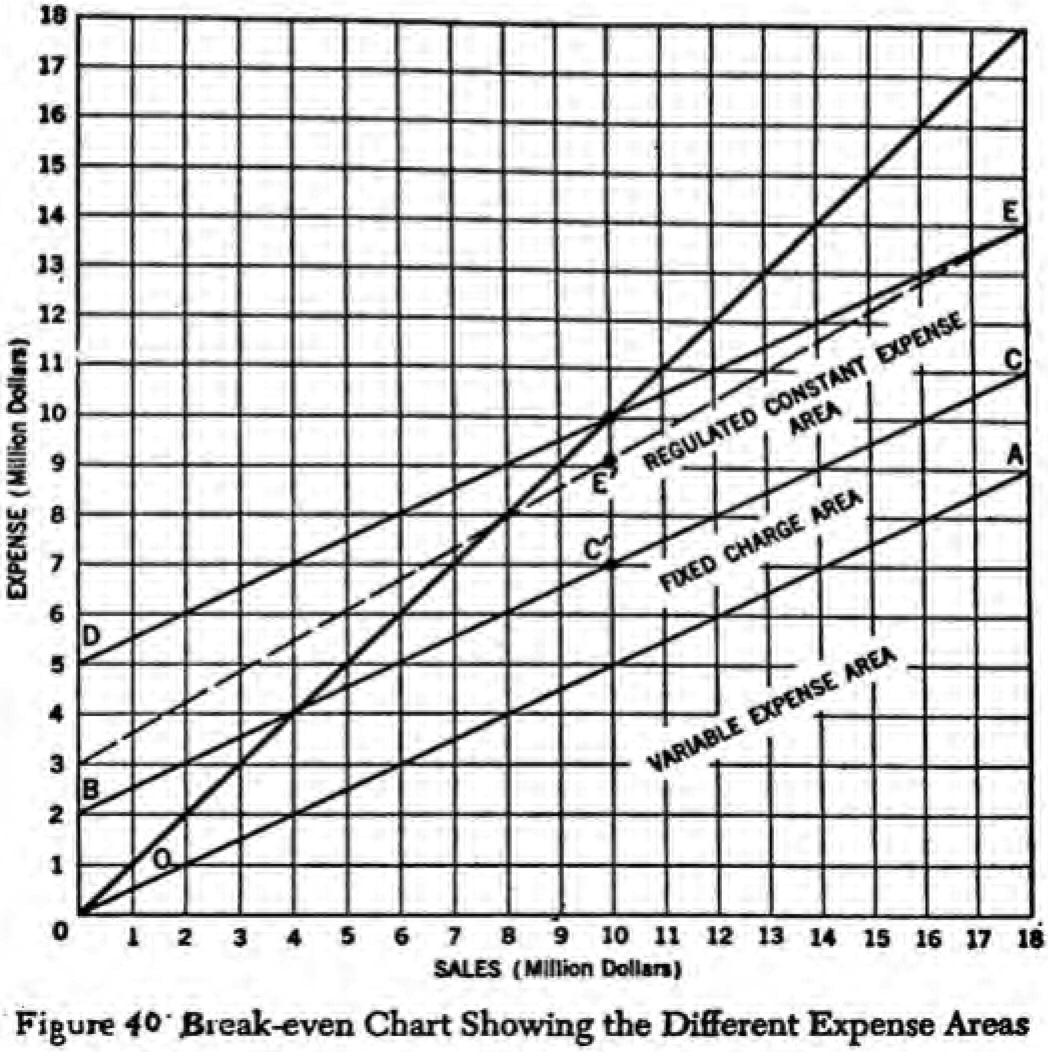

Figure 40 Break-even Chart Showing the Different Expense Areas

A company, in anticipation of annual sales of 18 million dollars, sets up a budget of expenses which results in

Fixed charges before bond interest	= \$2,000,000
Regulated constant expenses	= \$3,000,000
Total variable expenses for \$18 million sales	= \$9,000,000

This budget results in a break-even chart as shown in Figure 40, in which the line O-A defines the total variable expenses; the line B-C defines the fixed charges; and the ordinates in the area B-D-E-C show the present budgeted regulated constant expenses. With this budget the company will break even before interest at annual sales of 10 million dollars. The equation of profit before interest charges is

$$P = 50\% \text{ of sales} - \$5{,}000{,}000$$

In general terms it is written

$$P = (1 - b)X - a$$

Let

B = the amount of bonded debt (dollars)
S = the amount of preferred stock (dollars)
C = the amount of common stock (dollars)
$\%$ = the percent of interest on the bonds or percent of dividends on the preferred stock
T = the Federal income taxes

then

1. The number of times bond interest is earned is

$$\frac{P}{\%B}$$

2. The number of times the preferred stock dividends are earned is

$$\frac{P - \%B - T}{\%S}$$

3. The percentage earned on the common stock is

$$\frac{P - \%B - T - \%S}{C}$$

However, if the company has set up a budget of regulated expenses such that these are gradually reduced as annual sales decline from C-E at \$18,000,000 annual sales to C′-E′ at \$10,000,000 annual sales,

then the probability of earnings is determined by the total expense trend E-E′ for which the profit becomes

$$P = 38.9\%X - \$3,000,000$$

The method followed in the preparation of Figure 39 could also be applied to the analysis of the above data so as to bring in clear perspective the relation of earnings to sales for each class of securities for the entire range of anticipated sales. The construction of such a chart takes very little time and in a few moments the probabilities of earnings on investments and their margins of safety are quickly determined.

II. COMPARISON OF TWO OR MORE COMPANIES AS TO EARNINGS

A. The income-expense relationships of the break-even chart disclose the profit or loss in terms of sales income. But since the investors in business enterprises are concerned primarily with the probable profit per dollar invested, it becomes necessary to evaluate business from this standpoint also. If two businesses, operating at full capacity, both show the same total profit but the one business has twice the invested capital of the other, then the one is half as profitable as the other from the standpoint of the capital invested. But all investors do not share alike in the earnings.

Assume two businesses, A and B, each having earnings of $100,000 and each a total invested capital of $1,000,000. The earnings are 10 percent on the total capital invested in each company. If Business A has its capital represented by $400,000 of 7 percent preferred stock and $600,000 of common stock, then the holders of preferred shares will receive $28,000 or 7 percent on their invested capital, while the holders of common stock will be credited with $72,000 or 12 percent on their invested capital.

If Business B has only common stock in its capital structure, then each shareholder will earn 10 percent on his invested capital.

B. The difference between two businesses with respect to the probability of earnings over a wide range of sales may be shown by means of these charts, although their profit and loss statements upon superficial examination may indicate that both businesses have about the same earning capacity. A certain company, for example, let us call it Company A, shows annual sales of $2,000,000 and net profits of 15 percent on sales, or $300,000. The profit and loss statement of Company B, which manufactures and merchandises a wholly different

product, also shows annual sales of $2,000,000 and net profits of 15 percent on sales, or $300,000. Let it be further assumed that both companies are operated at full capacity. An examination of the constant total costs and variable total costs shows the following:

	Company A	Company B
Constant total costs	$ 700,000	$ 200,000
Variable total costs	1,000,000	1,500,000
Total	$1,700,000	$1,700,000
Sales	2,000,000	2,000,000
Net profit	$ 300,000	$ 300,000

Upon constructing the break-even charts for each company, and superimposing them, we find some important differences in their earning characteristics.

These charts are shown in Figure 41. The one constructed with solid

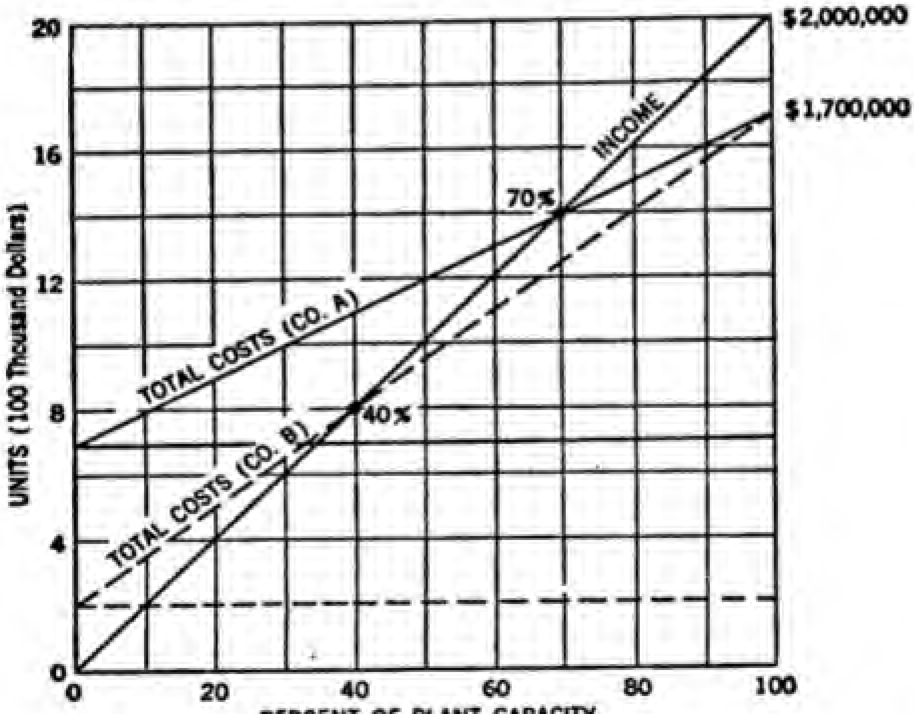

Figure 41. The Break-even Chart of Two Companies Making the Same Profit at 100 Percent Capacity

lines is for Company A; that with broken lines, for Company B. The two companies earn the same total profit when operated at full capacity Company A breaks even at 70 percent, whereas Company B breaks even at 40 percent capacity. Accordingly, Company B makes a profit over

a wider range of sales. It has more elasticity. It can be operated at a profit of approximately $140,000 when Company A shows no profit for the same volume of sales. Company B breaks even when Company A shows a loss of $300,000. Company B is typical of those industries in which there is little plant investment and consequently the fixed charges are low. The principal costs are for materials and labor. Company A, on the contrary, represents those businesses in which the fixed charges or constant total costs are high, such as highly mechanized industries. The management of Company B can discharge its help as sales decline, but Company A finds itself in a wholly different situation in a declining market, and one in which it cannot readily adjust expenses to income.

III. THE EFFECT OF PLANT DESIGN ON THE ECONOMIC CHARACTERISTICS OF A BUSINESS

The investment banker is interested in the physical features of the factory of a company seeking funds, for several reasons. One reason is that costs of production and their control are largely influenced by the physical lay-out and the general features of the design. The extent to which the costs of producing goods at different rates of production can be regulated is dependent on the extent to which the forces of production can be adjusted or controlled. If a plant is so designed that it is a large single-processing unit and that any production whatsoever from, say, 10 percent capacity to 100 percent capacity requires the running of the whole plant, the conditions of operation are as indicated diagrammatically in Figure 41.

Figure 41 illustrates a plant in which the raw materials pass through a series of processes in succession, and the labor required to run the machines and the services supporting labor are practically the same, no matter what amount of material is being processed. Such plants as paper mills, bakeries, sugar mills, and cement plants are generally designed along these lines. Because of the verv nature of the design, such plants require about the same amount of labor and services when running light as when running to full capacity, and therefore their controllable costs for different rates of output are comparatively few. At the other extreme of plant design are such plants as those typified by certain forge shops in which there is a group of complete producing units. Figure 42 illustrates a design of this kind. In a forge shop, Machine 1 would represent a heating furnace and Machine 2 a hammer. Each group of units is capable of converting raw materials

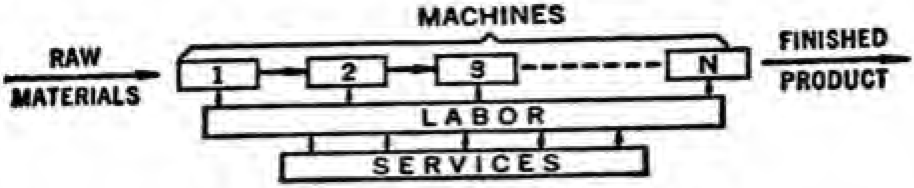

Figure 42. A Single Unit Plant Lay-out

into finished products. Accordingly, with a decline in demand from 100 percent capacity to, say, 75 or 70 percent capacity, one of the groups of units may be shut down and the attending labor and certain services such as the indirect labor needed to handle materials at one group and the power and heat to operate the group may be dispensed with. When the demand falls under 50 percent, another group of units may be shut down, with still further reductions in the cost of labor and some services. Therefore, a plant designed according to these principles of operation has a comparatively greater range of controllable costs, and the economic characteristics as shown by a break-even chart will be quite different from those for a plant of the type first described, particularly in showing a lower break-even point, owing to the greater change in costs with output.

Between these two extremes of design there are any number of modifications and combinations, each of which establishes certain limits to the variations permissible in the controllable total costs.

It is obvious that this method of analysis has many other important applications. In fact, the recent trend toward automation has created a new field of application for this method. The increasing use of automatic equipment tends to reduce the number of lay-outs similar to the one illustrated in Figure 43 and to increase the number of those illustrated in Figure 42. Actually, it may be expected that in the years

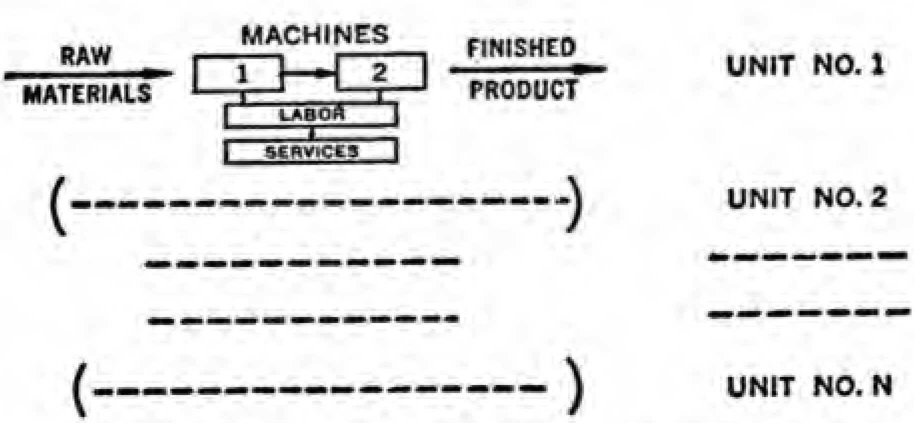

Figure 43. A Multiple Unit Plant Lay-out

to come the economic structure of the "process industries," * characterized by a higher ratio of constant costs and a higher break-even point will tend to become that of many other industries, metal-working plants, automobile manufacturers, etc., as a result of the trend toward automation. For all industries following such a trend, this will mean a substantial increase in the margin of profit at a volume of production approaching the full capacity of the plant. It will also mean a greater vulnerability to any slack in sales and to seasonal variations. Such factors should of course receive full attention in analyzing a business for the purpose of investment and should be considered in the light of probable developments among competitors. An investor is always likely to be concerned with the ability of an enterprise to adjust to future drops in sales or to an irregular pattern of production. At the same time, it should be recognized that, in the long run, a business cannot compete successfully with businesses that can produce more economically because of their more modern equipment and of their ability to work at or near capacity.

IV. THE EFFECT OF FEDERAL INCOME TAXES ON EARNINGS

At the present time, the problem of income taxes is of considerable concern to the investors in a company's securities. To get a clear picture of what a company's economic characteristics are, it is necessary to find the trend of total expenses before taxes since the amount of taxes paid is not part of the economic performance of a company. To illustrate, the total expenses *before* taxes in relation to sales of the International Paper Company for the years 1948 to 1955 are plotted as shown in Figure 44. For purposes of comparison, the total expenses *after* taxes are also plotted. Data are in Table XXXV (from Moody's *Industrial Manual*).

This chart shows that for this company, the trend before taxes closely approximated

$$\text{Expenses} = \$25{,}000{,}000 + 75\% \text{ of sales}$$

From this basis, it is possible to estimate the effect of taxes on earnings. For example, should annual sales be 800 millions of dollars, the probable profit before taxes may be anticipated to be:

$$\text{Profit } \textit{before} \text{ taxes} = (\$800{,}000{,}000 \cdot 25\%) - \$25{,}000{,}000 = \$175{,}000{,}000$$

* For a more detailed study of this economic structure, see pp. 290*ff*.

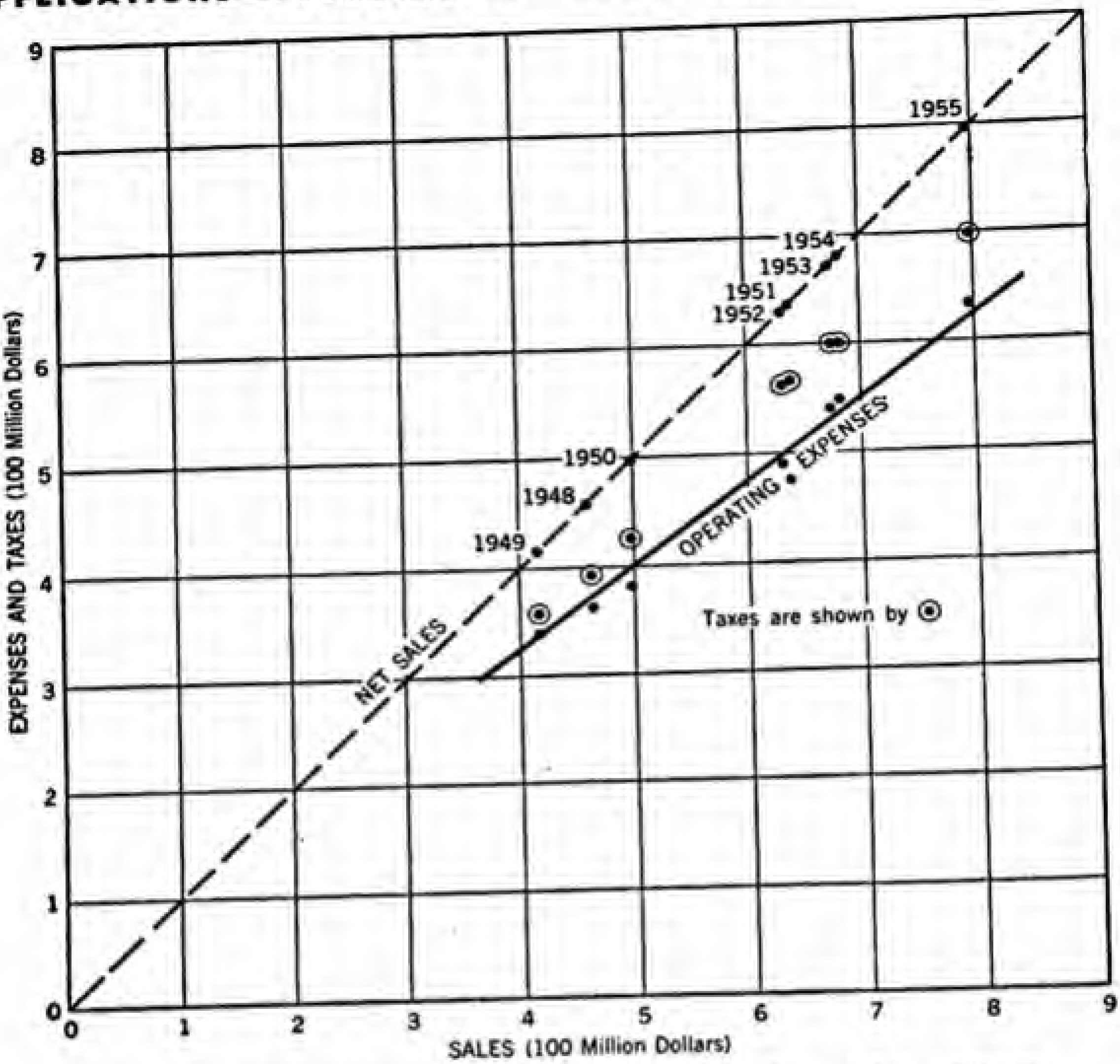

Figure 44. International Paper Company Profit and Loss Chart, 1948–1955

TABLE XXXV

INTERNATIONAL PAPER COMPANY

Year	Net Sales	Operating Expenses	U.S. Federal Income Tax *(including Excess Profit Tax)*
		(Millions of Dollars)	
1948	458.8	361.5	30.3
49	415.5	339.4	25.2
50	498.4	379.8	45.4
51	637.3	474.9	90.5
52	631.4	490.6	72.8
53	673.5	537.4	63.0
54	681.1	547.0	53.0
55	796.4	632.0	65.6

Accordingly, the probable profit *after* taxes may be anticipated to be

$$\text{Profit } \textit{after} \text{ taxes} = \$175{,}000{,}000 - \text{taxes}$$

Actually when conducting a study for the purpose of investment, it is necessary to investigate matters such as:

1. *The possibility of tax liabilities.* This possibility results from the fact that the amount of taxes paid depends to a certain extent on the accounting practice followed in a given business. Speaking only of cases where there is no question of an attempt to defraud, but recognizing that tax laws are subject to divergent interpretations, there is always the possibility that some of the expenses deducted from the income during the past few years may be disallowed after the tax returns of the company have been reviewed by the Internal Revenue Service. In addition to creating a liability for taxes past due, it may also affect the tax structure of the future years. This shows the need for reviewing the tax deduction policy of a company in the light of tax laws and jurisprudence. A tax expert should be consulted to report about deductions that in his opinion might be subject to further review, such as executives' salaries, traveling and entertainment expenses, depreciation, or deductions resulting indirectly from the methods of inventory valuation.

2. *The impact of the investment that is under consideration.* One way or another, the investment is likely to influence the tax structure. If the money is being used to modernize the plant facilities, the tax deductions for depreciation purposes will increase. If the investment is in the form of bonds or notes, the interests paid are deductible for income tax purposes. These and other similar problems should be given attention.

3. *The possibilities of changes in the tax structure.* These possibilities should also receive attention. They are not related to changes in tax legislation which, of course, can occur but can hardly be predicted. Instead, these possibilities are related to the influence of past policies upon the future tax structure of the company. Typical of such problems are those created by the policy of taking advantage of rapid depreciation laws. These laws which are reviewed in Chapter IX have made it possible for some businesses to depreciate their equipment at a sometimes very rapid rate. As a result, a few years after the investment has been made, a radical change in the tax structure may result from the fact that the same equipment is still being used although no more depreciation expense can be deducted from the profit for income tax purposes. In some cases this may result in a very substantial decrease in a mere book expense (the depreciation expense) and a very

substantial increase in tax liabilities, which are to be paid in cash. This may increase the nominal profit in the books and at the same time create a serious problem of working capital shortage.

V. THE MERGER OF TWO COMPANIES

In recent years, the process of merging industrial enterprises with each other has been practiced at an increasing rate. One of the reasons has been the possibility of benefiting by very substantial tax reductions by merging a profitable company with a non-profitable one, which had a "tax deduction backlog." In such a case the merger brings to the profitable company the privilege of deducting from its own present and future profits several years of losses suffered by the other company. Within certain limits, the tax laws permit such a procedure.

Other reasons for the growing trend of mergers are the advantages resulting from operating larger enterprises. Because of its size, the consolidated enterprise can often operate more economically than each of the companies could do prior to the merger. The financing of its working capital is also made easier, because it is often easier for a larger enterprise to obtain loans from banks and insurance companies.

When a merger of two companies is contemplated, it is desirable to determine the probable trend of expense to sales of the consolidated company. This will assist the executives concerned or the investment banker in visualizing some aspects of the results of the combination of the two companies.

Actually the trend of the consolidated company is likely to be different from the simple combination of the trends of the two companies. This is because, as a rule, the merger is not merely a summation of assets and liabilities but also an opportunity of improving the conditions of operations.

If two companies K and L are to be merged, and if y_K is the trend of expense to sales of the K company, as determined by its break-even chart, and y_L that of the L company, we are concerned with the trend y_M of the consolidated company, rather than with y_{K+L}, the mere summation of trend y_K and trend y_L.

An effective approach to determine y_M is first to determine y_{K+L}, and then determine y_M by applying the method of differential profit control.

To illustrate, let us assume that the two companies K and L to be merged have annual sales of \$10,000,000 and \$20,000,000 respectively and that at the time of the merger the total expense trends of the break-even charts of each company are defined by the following equations:

$$\begin{aligned} y_K &= a_K + b_K x \\ &= \$2{,}000{,}000 + .4x \\ y_L &= a_L + b_L x \\ &= \$3{,}000{,}000 + .55x \end{aligned}$$

The trend to be defined is y_M, the total expense trend of the break-even chart of the new enterprise resulting from the merger of the two companies, K and L, namely

$$y_M = a_M + b_M x$$

We must compute a_M, the constant expenses of the new company, and b_M, the ratio of its variable expenses to sales. The first step is to define the trend y_{K+L} of the break-even chart of the new company at the time of the merger, before anything has been done to take advantage of the merger so as to operate more economically. This trend, prior to any improvement of the conditions of operations is determined by combining the equations y_K and y_L. The general equation of the total expense of the combined trend is:

$$y_{K+L} = a_{K+L} + b_{K+L} x$$

where:

the value a_{K+L} is determined by the summation:

$$a_{K+L} = a_K + a_L = 2{,}000{,}000 + 3{,}000{,}000 = \$5{,}000{,}000$$

The value b_{K+L} is determined by computing the ratio of the summation of the variable expenses (v_K and v_L) to the summation of the sales (x_K and x_L) of the two companies at the time of the merger, i.e.:

$$b_{K+L} = \frac{v_K + v_L}{x_K + x_L}$$

In the case we are taking as an illustration, the variable expense of the K company at the time of the merger was

$$v_K = b_K \cdot x_K = .4 \times 10{,}000{,}000 = 4{,}000{,}000$$

and that of the L company

$$v_L = b_L \cdot x_L = .55 \times 20{,}000{,}000 = 11{,}000{,}000$$

Thus

$$b_{K+L} = \frac{4{,}000{,}000 + 11{,}000{,}000}{10{,}000{,}000 + 20{,}000{,}000} = \frac{15}{30} = .5$$

The trend of the combined break-even chart at the time of the merger is therefore

$$y_{K+L} = \$5{,}000{,}000 + .5x$$

This is *not* going to be the trend of the new company which results from the merger.

This new trend will be

$$\begin{aligned} y_M &= (a_{K+L} + \Delta_a) + (b_{K+L} + \Delta_b)x \\ &= (\$5{,}000{,}000 + \Delta_a) + (.5 + \Delta_b)x \end{aligned}$$

where Δ_a and Δ_b represent respectively the differences in constant expense and variable expense to be expected as a result of the merger. If the merger is to be profitable on the basis of a change in the condition of operations, at least one of the two, and maybe both Δ_a and Δ_b, should be negative factors. They may, for instance, result from a reduction in the administrative overhead or a reduction in the number of salesmen due to a consolidation of efforts, from a reduction in the cost of material due to a consolidation of purchases, from an improvement of the sales mixture or even from such major decisions as the closing of some of several plants or warehouses.

The computation of Δ_a and Δ_b is to be conducted as previously indicated when studying the application of the method of differential profit control to the case of the RST Company.*

At the time of the merger, it is likely that several possibilities can be taken under consideration before a final decision is being made as to how to modify the conditions of operation to take the maximum advantage of the possibilities offered by the merger. The preparation of a differential break-even chart † makes it possible to show clearly the respective advantages and disadvantages of each alternative related to the projected merger.

* See above pp. 117*ff*.
† See above Fig. 20, p. 128.

VII

APPLICATIONS—PROBLEMS OF MANAGEMENT

THE BREAK-EVEN CHART of a company is useful to management because it establishes the characteristics or standards of all classes of expenses in relation to output and sales. Without such standards it is not possible to exercise scientific control of expenses as output or sales rise or fall from time to time. For example, if in a given month the manager of a factory is informed that the direct labor cost is $10,000 more than in the previous month, how can he know if the increase is justified or that it is in proportion to increased output unless he has a standard by which to judge? Budgeted regulated expenses may also easily get out of line unless compared often with standards shown in the break-even chart.

Furthermore, in every business there are numerous situations to be confronted and discussions involving expenses to be held, all of which affect the economic characteristics of the business. The break-even chart method of analyses serves as a means for answering many questions of this nature, some typical examples of which follow.

A. CONTROL OF EXPENSES

The trend of the break-even chart provides a standard to which the actual expense for any given period can be compared. Experience has shown that, as a rule, a break-even chart on a monthly basis is very well adapted to the control of expenses, since it is readily related to the monthly profit and loss statement. When expenses are being prebudgeted, the break-even chart can be used for the purpose of preparing the budget as well as for control purpose.

Effective expense control consists of determining the *variance* between the actual expense and the standard expense, as defined by the break-even chart and/or the budget and, if the magnitude of the variance warrants it, in analyzing it. If and when needed, managerial action can then be taken.

To facilitate this analysis of variance, it is advisable to break down the expenses of the entire business according to the divisions of the business. In fact, every department head responsible for the expenditure of funds should be placed under control with reference to such expenditures. It is also necessary to relate the expenses to the products that are being manufactured. In the *multi-product industry*, i.e., in enterprises where the number of products manufactured is great (reaching 100 or 1000 or more) there is a need for relating the break-even chart to the sales mixture. This can be done by using the sales-mixture chart and by applying the method of differential profit control.* If on the contrary the number of products is reasonably small, it is advisable to prepare a break-even chart for each product.

1. A Break-Even Chart for Each Product Manufactured

One of the authors of this text was appointed president of a company for the purpose of putting it on a profitable basis. The company manufactured five different products, which will be designated A, B, C, D, and E. One of the problems which presented itself was to determine the relative profitableness of each product and also how much sales were required at present prices for each to break even. The first thing that needed to be done was to assemble the facts of expense for each product manufactured. This was very difficult since the accounting system used was not adapted to this purpose. After a careful analysis and check on the known facts *and the preparation of*

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* See above pp. 117*ff*.

a budget of expenses for each division of manufacture and for the business as a whole, the following results were obtained. An examination of past sales and trends indicated that for the next year these products should be sold as follows:

Product	Annual Sales	Percent
A	$2,000,000	33⅓
B	520,000	8⅔
C	2,520,000	42
D	480,000	8
E	480,000	8
Total	$6,000,000	100

The constant total costs for the business as a whole were estimated to be $2,250,000 and the variable total costs for sales of $6,000,000 were estimated to be $3,000,000. Upon examination of the constant total and variable total cost items, it was estimated that each group of products contributed to these in the following proportions:

Product	Percentage of Constant Total Costs	Percentage of Variable Total Costs
A	40	30
B	10	5
C	35	50
D	8	10
E	7	5
	100	100

From these data it was possible to construct a break-even chart for each product manufactured and, therefore, to deal intelligently with the economic problems associated with the manufacture and sale of each kind of product. Among other important information which such an analysis disclosed was the volume of sales per week which must be accomplished with each product in order to break even. In this case it was found that the break-even sales were as follows:

Product	Break-Even Sales (Weekly)
A	$31,400
B	6,100
C	37,800
D	9,100
E	4,850

The equations of expense trend of each product are as follows:

ANNUALLY

Product	A	expenses	=	\$900,000 + 45% sales
"	B	"	=	225,000 + 28.9% sales
"	C	"	=	787,500 + 59.7% sales
"	D	"	=	180,000 + 62.6% sales
"	E	"	=	157,500 + 31.3% sales

MONTHLY

Product	A	expenses	=	\$75,000 + 45% sales
"	B	"	=	18,750 + 28.9% sales
"	C	"	=	65,625 + 59.7% sales
"	D	"	=	15,000 + 62.6% sales
"	E	"	=	13,125 + 31.3% sales

WEEKLY

Product	A	expenses	=	\$17,300 + 45% sales
"	B	"	=	4,330 + 28.9% sales
"	C	"	=	15,120 + 59.7% sales
"	D	"	=	3,460 + 62.6% sales
"	E	"	=	3,020 + 21.3% sales

Thus, each product is expected to bring in, weekly, the following sales with expenses and profits as indicated:

	Weekly		
Product	Sales	Expenses	Profits
A	\$ 38,500	\$ 34,600	\$ 3,900
B	10,000	7,220	2,780
C	48,500	44,120	4,380
D	9,250	9,240	10
E	9,250	5,910	3,340
	\$115,500	\$101,090	\$14,410

Apparently Product D needed to be redesigned for more economical production at this volume of sales, or the processes of its manufacture improved, or it should be dropped.

With these facts in its possession the management was able to determine not only the amount of sales of each product needed to break even but also the extent to which each product was expected to contribute to the profits of the business not only by sales but also by the

control of expenses. The above facts would not be available through the break-even analysis of the business as a whole.

2. *A Break-Even Analysis for Each Division of the Business*

A certain company* manufactures its products in two plants, one located in the East and the other in the Midwest. It has four division offices for supervision of its sales; each one has a number of branch offices under its direction. Its general offices are located in New York City. The management needs to know how much it costs to manufacture its products in each of its plants and also how much it costs to deliver its products to its customers in each territory which it serves. The company manufactures a bulk product which is sold by the pound. Without going into elaborate detail, the results of analysis are as follows.

a. *Total Annual and Monthly Sales and Expenses.* The annual sales and expenses of the business for the approaching year are estimated to be as follows.†

Annual sales	$2,555,000
Annual expenses of manufacture and administration	1,200,000
Annual expenses of distribution	1,000,000
Total expenses	$2,200,000
Annual profit	355,000
Monthly sales	$212,917
Monthly expenses of manufacture and administration	100,000
Monthly expenses of distribution	83,333
Total expenses	$183,333
Monthly profit	29,584

To assure this profit, the expenses of each department of the business must be brought under control. Since the break-even analysis for manufacture has been given adequate consideration in previous examples, the analysis of the expenses of distribution will be emphasized in this example.

b. *Expenses of Distribution.* The total monthly budget of the expenses of distribution was found to be as follows.

* One of the authors was vice president and general manager of this company.
† This is taken from an actual case but the figures are given in round numbers.

	Total	Fixed	Variable
General sales office (New York)	$ 7,000	$ 7,000	$——
Division expense	11,600	11,600	——
Branch expense	50,500	40,000	10,500
Freight expense	14,233	——	14,233
Total	$83,333	$58,600	$24,733

With anticipated monthly sales of $212,917, it appears that the trend of total distribution expenses per month should be

$$\$58,600 + 11.6\% \text{ of sales}$$

But each territorial division of the business must do its part if the company is to be successful. What should be expected of each of the territories? The monthly budget of operations of each territory was found to be as follows.

	Eastern	New England	Central	Western
General sales office *	$ 2,100	$ 1,180	$ 1,000	$ 2,720
Division expense	3,400	2,300	1,800	4,100
Branch expense	13,300	9,400	9,100	18,700
Freight expense	3,700	3,800	2,500	4,233
Total	$22,500	$16,680	$14,400	$29,753
Constant	16,000	11,500	10,200	20,900
Variable	6,500	5,180	4,200	8,853
Sales	64,300	36,000	30,600	82,017

* General sales office expense is apportioned to the territorial division in proportion to anticipated sales.

Accordingly, the probable expenses of each territorial division should follow the trends as stated below:

Eastern	$16,000 + 10.1% sales
New England	11,500 + 14.4% sales
Central	10,200 + 13.7% sales
Western	20,900 + 10.8% sales

How much must each territorial division sell to break even *on its own expenses?*

From the above equation these are found to be:

Eastern $$\frac{\$16,000}{1 - 0.101} = \$17,800$$

New England	$\dfrac{\$11{,}500}{1 - 0.144}$	$= \$13{,}450$
Central	$\dfrac{\$10{,}200}{1 - 0.137}$	$= \$11{,}800$
Western	$\dfrac{\$20{,}900}{1 - 0.108}$	$= \$23{,}400$
Total		$66,450

But the territorial divisions through their sales must also carry the expenses of manufacture and administration. These, as previously noted, amount to $100,000 monthly for sales of $212,917.

An analysis of the functional nature of each item of these expenses shows that $55,000 is constant and $45,000 is variable.

Accordingly, the trend of monthly expenses of manufacture and administration is:

$$\$55{,}000 + 21.1\% \text{ sales}$$

To find the break-even point for the business as a whole, the trend of total expenses of the business as a whole must be determined. This trend is:

Manufacture and administration	$55,000 + 21.1% sales
Distribution	58,600 + 11.6% sales
Total	$113,600 + 32.7% sales

From this trend, it is found that the break-even point of the business as a whole is

$$\text{Monthly break-even} = \frac{\$113{,}600}{1 - 0.327} = \$169{,}250$$

How much business should each territorial division do to meet the break-even requirements of the business as a whole? To answer this question, the expense of manufacture and administration must be apportioned to each of the territorial sales divisions. One method of making such an apportionment is to distribute the constant expenses of manufacture and administration to the territorial divisions according to their anticipated sales. That is, according to the following percentages:

Division	Anticipated Sales	% of Total
Eastern	$64,300	30.2
New England	36,000	16.8
Central	30,600	14.7
Western	82,017	38.3
Totals	$212,917	100.0

Each division would also carry the variable expenses of manufacture and administration (21.1%). Accordingly, each territorial division, to absorb its proportion of the expenses of the business as a whole, must meet its own expenses of operation plus its proportion of the manufacture and administration dollar expenses as above defined. This results in:

Division	Own Expenses	Proportion of Manufacture and Administration Expense	Total
Eastern	16,000 + 10.1% sales	16,550 + 21.2% sales	32,550 + 31.3% sales
New England	11,500 + 14.4% sales	9,250 + 21.2% sales	20,750 + 35.6% sales
Central	10,200 + 13.7% sales	8,100 + 21.2% sales	18,300 + 34.9% sales
Western	20,900 + 10.8% sales	21,100 + 21.2% sales	42,000 + 32% sales

Each territorial division to carry its portion of the business as a whole will break even as follows:

Eastern Division

$$\text{Break-even} = \frac{\$32,550}{1 - .313} = \$47,380$$

New England Division

$$\text{Break-even} = \frac{\$20,750}{1 - .356} = \$32,200$$

Central Division

$$\text{Break-even} = \frac{\$18,300}{1 - .349} = \$28,1\text{[illegible]}0$$

Western Division

$$\text{Break-even} = \frac{\$42,000}{1 - .32} \quad \$61,750$$

Total [illegible]40

The profits anticipated from each territorial division are:

Eastern Division

$$\begin{aligned} \text{Profit} &= \text{sales}\,(1 - \text{b}) - \text{a} \\ &= \$64{,}300\,(.687) - \$32{,}550 \\ &= \$11{,}624 \end{aligned}$$

New England Division

$$\begin{aligned} \text{Profit} &= \$36{,}000\,(.644) - \$20{,}750 \\ &= \$2{,}434 \end{aligned}$$

Central Division

$$\begin{aligned} \text{Profit} &= \$30{,}600\,(.651) - \$18{,}300 \\ &= \$1{,}621 \end{aligned}$$

Western Division

$$\begin{aligned} \text{Profit} &= \$82{,}017\,(.68) - \$42{,}000 \\ &= \underline{\$13{,}772} \end{aligned}$$

Total

$$\text{Profit} = \$29{,}451$$

Without an analysis of the above kind it is not possible to establish a rational norm of anticipated expenses and profits for each division of the business, and therefore no rational basis of management and control can be established.

3. *A Break-Even Chart for Each Department*

The manager of a department of manufacture is in charge of expenditures for labor both direct and indirect, for materials both direct and indirect, and for certain items of factory expense such as maintenance and repairs. Other items of expense charged to his department may not be completely under his control and may be shared with other department heads on the same basis of apportionment of such expenses. If, for example, there is a central toolroom serving several departments, the responsibility of the manager of a given department for his particular portion of the toolroom expenses is not always easily determined. Other items, properly chargeable to the cost of manufacture of a given product, such as depreciation, insurance, local taxes, heat, light, and power, are not under the control of the manager of any particular department and hence no one manager can be held accountable for them.

Accordingly, no control of expenses incurred by the manager of a given department can be inaugurated until the accounting department sets up a budget of the items of expense for which the manager can be held responsible. In small manufacturing companies, a given

production division may be responsible for the partial or complete manufacture of several types of products. A forge shop, a foundry, a punch press department, and an assembly department, in which all the products a company manufactures are assembled, are examples of such divisions in manufacturing operations. The preparation of a break-even chart to be used for control purposes in such cases demands that the unit of output be determined first. In the case of a forge shop in which the forgings are all of the same general type, the unit of output may be the pound. The same is true of a foundry, again provided that the castings are of the same general character.

In those cases where the output may be measured in pounds, a monthly break-even chart, as shown in Figure 45, may be prepared and used for control purposes. The base of the chart is laid out in units of 1,000 pounds per month. The vertical ordinates are laid out to the scale of 1,000 dollars. The income lines may be laid out for

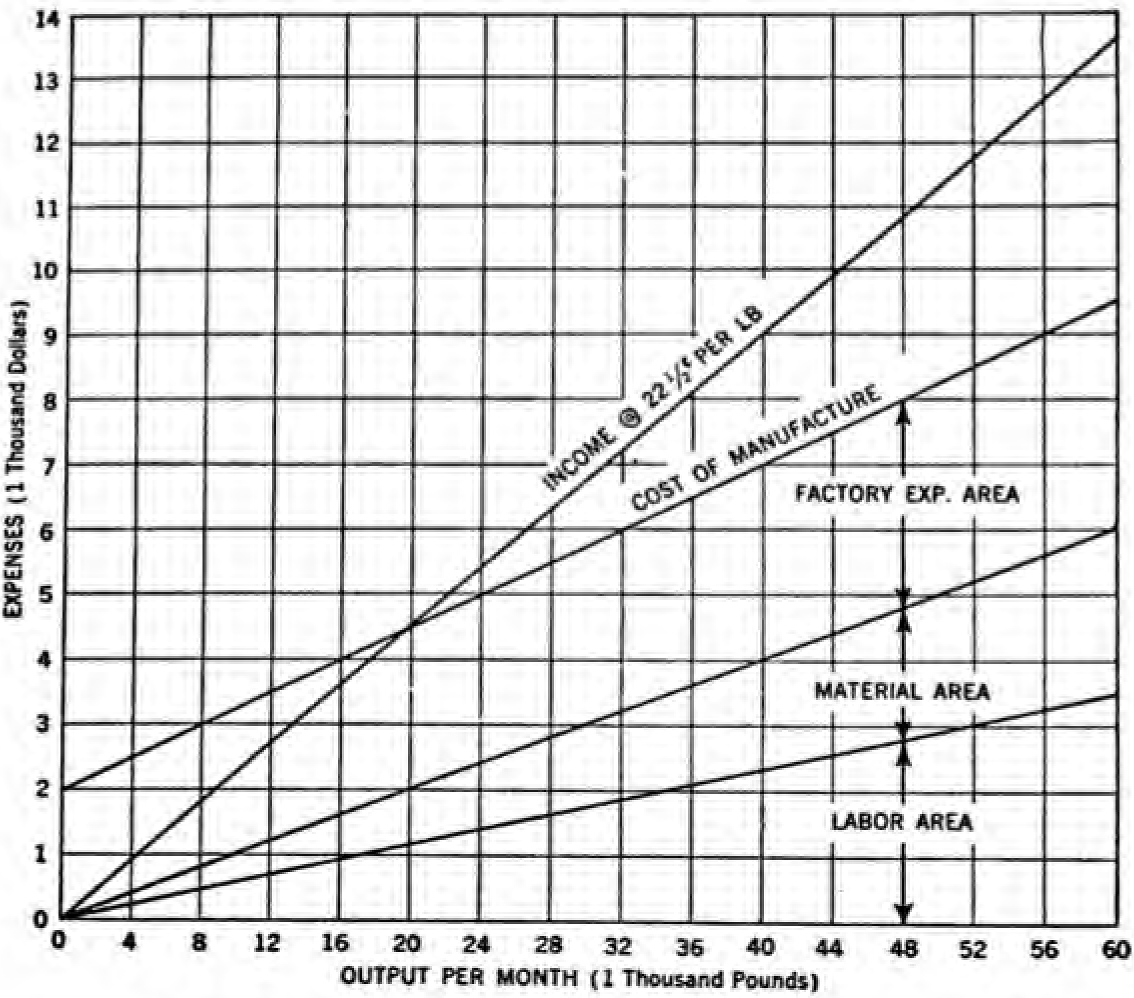

Figure 45. Budget of Monthly Expenses in Department "A"

several probable unit selling prices per pound to show the probable maximum break-even points for probable maximum and minimum selling prices. In the example selected for illustration, "Department A," the selling price per pound is fixed at 22.5¢. How can the selling prices be determined of *a part such as a forging or a casting* which is unfinished in the department to which the break-even chart relates and which is later to be machined and assembled in another department as part of the product as sold? The writers have found that for control purposes the probable selling price may be found by the following method:

a. Find the ratio of the *budgeted cost* of manufacture of the completed product to the selling price of the completed product.
b. Divide the budgeted cost of manufacture of the department by the above ratio to find the corresponding probable income. In the example shown for illustration in Figure 45, the budgeted output of Department A is 60,000 pounds per month. The cost of manufacture for the *budgeted output* is estimated to be $9,500.

The ratio of the budgeted cost of manufacture of the completed product to its selling price is approximately 0.70. Dividing $9,500 by 0.70 there is obtained the approximate quantity $13,500 which is equivalent to a selling price of 22.5¢ per pound.

To show how the chart is useful for control purposes, let it be assumed that in a given month the output is 48,000 pounds. What should the factory expense and the material and labor costs for this output be? The chart shows that the factory expense should be $3,200, the materials cost should be $2,000 and the labor cost $2,800. These may now be compared to the actual costs reported by the accounting department and appropriate action, if needed, may then be taken. The break-even chart may be accompanied by a tabular budget each month if the business is one in which the monthly production varies over an appreciable range of output.

The following Figure 46 is reproduced from the writers' files to illustrate the form of such a budget as devised and used for a particular plant of a business manufacturing a bulk product sold by the pound. The explanations or comments were not filled in, in this report, because an accompanying letter was substituted. If the management thinks in terms of cost per pound, it may be found by Figure 45 that at a monthly output of 60,000 pounds the cost per pound is 15.83¢, at 48,000 pounds per month the cost is 16.66¢, and at 28,000 pounds per month the cost is 19.64¢ per pound. If, for example, it is anticipated

1947 BUDGET **REPORT NO. 7.**

MONTHLY REPORT OF PLANT "A" FOR MONTH ENDING June 1947

EXPENSES	AMOUNT APPROPRIATED FOR MONTH	EXPENDED THIS MONTH		EXPLANATION OR COMMENT
Raw Materials Used	$ 12951.37	10 797	45	
Direct Labor	4628.00	4 087	80	
Foremen's Salaries	810.00	785	16	
Operating Supplies Used	602.91	653	78	
Packing Supplies Used	1838.00	1 734	37	
Repairs Productive Depts.	1925.00	1 525	29	
Fuel	2548.00	1 637	89	
Taxes	169.00	187	28	
Fire Insurance	328.14	300	41	
Total Plant Expenses	37550.48	32 233	83	

Figure 46. A Typical Tabular Weekly Budget and Report

that in Department A the output for any given month is to be 56,000 pounds, then the budget for the major items of the cost of manufacture will be:

Factory expense	$34,000
Materials	23,500
Labor	32,500
Total	$90,000

For effective control, these major items of expense should be broken down into their details and according to their account classifications. The data of the break-even charts for all the departments, when combined, will, of course, give the break-even chart for the business as a whole.

B. ADAPTATION TO EXPENSE CHANGES

1. Change in Variable Expenses

The several rounds of wage increases and in materials costs which have occurred in the past few years have posed some serious problems to management. When the increases in wages and materials costs are reflected in the break-even chart, the effect of these charges on earnings is brought to sharp focus. How is the break-even chart to be adapted to the increased expenses?

To illustrate, let it be assumed that the labor cost of a given manufacturing company is 30 percent of the selling price and that a 10 percent wage increase is granted. Let it be assumed further that before the wage increase is granted, the trend of total annual expenses of the business is:

$$y = \$500{,}000 + 74\% \text{ of sales}$$

The new trend in total annual expenses will be reflected wholly in the variable costs which, since their increase is 3 percent of the selling price of the product, will now be 77 percent of sales. The new trend of total annual expenses will therefore be:

$$y = \$500{,}000 + 77\% \text{ of sales}$$

If, for example, the company is presently operating with annual sales of $3,000,000, the profit before the 10 percent wage increase is:

$$\begin{aligned} p &= x\,(1 - b) - a \\ &= \$3{,}000{,}000\ (0.26) - \$500{,}000 \\ &= \$280{,}000 \end{aligned}$$

After the 10 percent wage increase is granted, the profit will be 3 percent less on sales of $3,000,000, or $280,000 — $90,000 = $190,000; a decline of 32 percent in profits.* For the company to make the same profit it did before granting the wage increase of 10 percent, it will now have to increase its sales to an amount determined as follows:

Let x' = the new sales
x = present sales
b' = the new variable cost ratio
b = the present cost ratio

Then, to make the same profit as before:

$$x'\,(1 - b') - a = x\,(1 - b) - a$$

or

$$x' = x\,\frac{(1 - b)}{(1 - b')} = \$3{,}000{,}000 \cdot \frac{0.26}{0.23} = \$3{,}390{,}000$$

Accordingly, in this situation, the sales must be increased by 13 percent if the company is to make the same profit after granting a 10 percent wage increase.

* The student should construct the break-even chart for before and after wage increase, and note the change in the break-even point.

2. *Change in Constant Expenses*

The growth of a business frequently raises the question of plant enlargement. On such occasions a prudent management will forecast the probabilities of profits and the shift in the range of sales in which a profit may be made. Plant enlargement results in an increase in fixed factory expense. There are increases in charges for depreciation, higher insurance and taxes, increased maintenance and repairs, and in other charges. Assume, for example, that a certain manufacturing business is operated with constant total expenses of \$550,000 per annum and that the ratio of variable total expenses to corresponding sales is 0.45. The business will break even at sales of

$$X = \frac{\$550{,}000}{1 - 0.45} = \$1{,}000{,}000$$

If the sales value of the product at 100 percent capacity is \$1,500,000, the business would break even at 66⅔ percent capacity. The profit at 100 percent capacity would be

$$P = X(1 - b) - a$$

where $X = \$1{,}500{,}000$

$$b = 0.45$$
$$a = \$550{,}000$$
$$P = \$275{,}000$$

If the plant is enlarged 33⅓ percent of present capacity, the sales value of the products of the enlarged plant, when run at the new full capacity, would be \$2,000,000. The constant total costs (a) would also be increased as above indicated. Assume this increase to be 20 percent, giving constant total costs for the enlarged business of \$660,000. Assume (b) to be unchanged. The business will now break even at sales of

$$X = \frac{\$660{,}000}{1 - 0.45} = \$1{,}200{,}000$$

If a profit of \$275,000 is to be made as before, when the plant was run at old full capacity and sales were \$1,500,000, it is found that the sales must now be equal to

$$\begin{aligned} X &= \frac{P + a}{1 - b} \\ &= \frac{\$275{,}000 + \$660{,}000}{1 - 0.45} = \$1{,}700{,}000 \end{aligned}$$

Accordingly, there must be at least $200,000 increase in business to justify the plant expansion. When the enlarged plant is operated at full capacity, that is, when sales are $2,000,000, the profit will be

$$P = \$2{,}000{,}000\,(1 - 0.45) - \$660{,}000 = \$440{,}000$$

If, however, the increased business should not be realized, and maximum sales were $1,590,000, the profit would then be

$$P = \$1{,}500{,}000\,(1 - 0.45) - \$660{,}000 = \$165{,}000$$

which is $110,000 less than before the plant was enlarged. And, if sales should decline to $1,000,000 annually, the business, instead of breaking even, would suffer a loss of

$$P = \$1{,}000{,}000\,(1 - 0.45) - \$660{,}000 = \$110{,}000$$

QUESTION: If the break-even point of a business is 75 percent of plant capacity, is there a hazard in having a single customer take, say, 30 percent of the output? If you were the customer and knew that you were taking 30 percent of the manufacturer's output, would you press him for a price reduction?

3. Fundamental Changes. The Limit Point L

Very frequently a company finds it necessary to change its methods of manufacture or its system of marketing or both, in order to meet new economic conditions. Sometimes it is found desirable to modernize a plant or part of a plant by changing the equipment and using new methods of manufacture as a means of reducing costs. In recent years, the development of automatized industrial equipment, which can substantially reduce the cost of production when working near full capacity but generally requires a high investment, has made this problem even more acute than it was in the past.

Managerial decisions in these matters always require making some assumptions as to future economic developments and therefore the taking of some risk. It is highly desirable, however, to limit as much as possible the extent to which arbitrary decisions must be made. This can be done by answering in quantitative terms such fundamental questions as:

—What will be the impact of the change upon our break-even point?

—Under what conditions of operation is the new set-up going to be more profitable than the old one?

—How long will it take before the investment has paid for itself?

The break-even analysis provides the data that are needed to answer these and similar questions.

Let us assume for example that a certain business considers modernizing one of its plants which has the economic characteristics shown by the solid line of the break-even chart of Figure 47. It is estimated that the modernization of this plant will increase the constant total costs

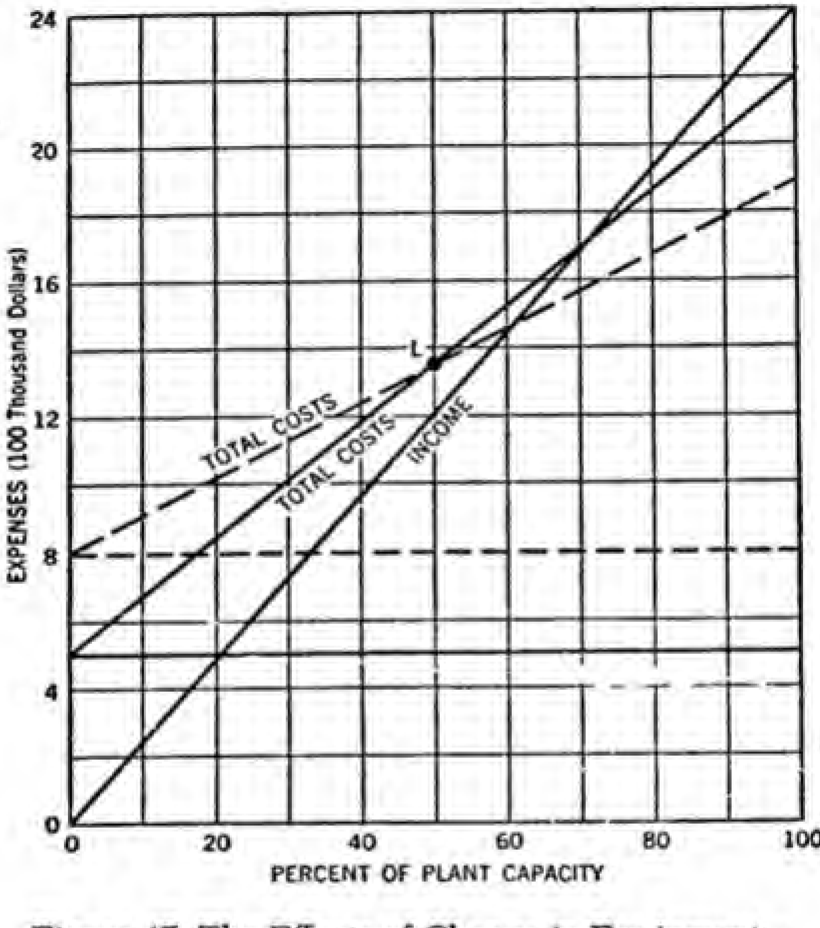

Figure 47. The Effects of Change in Equipment—
The Limit Point L

from $500,000 annually to $800,000, owing to increased interest charges, depreciation, and to a change in the economic characteristics of the labor expenses. It is also estimated that the variable total costs, whiob are $1,700,000 annually at 100 percent capacity, will now be reduced to $1,080,000, owing to reductions in labor costs and other operating expenses.

The effect of these changes may be shown by plotting a new break-even chart and comparing it with the former one as shown in broken lines in Figure 47. The comparison between the two trends provides

quantitative answers to the fundamental questions previously listed, namely:

1. The break-even point, in that case, is reduced from 70 percent of the original capacity to 60 percent. (It is desirable to specify *original capacity*, for in all probability total capacity will be increased as a result of the change.)

2. The two trends cross each other at what may be called the *limit point L*, which in this case is at 50 percent capacity. For any production higher than the limit point L the new set-up is more profitable than the old one. The reverse is true if production should decrease below the limit point L.

3. At 100 percent, or original capacity, the profits are estimated to be \$520,000 instead of \$200,000. This additional gain of \$320,000 should eventually be adjusted for tax liability and then compared to the investment required. The purchase price of the new equipment should also be adjusted to take into account the actual loss or gain resulting from the sale or the scrapping of the old equipment. In that case, for instance, it is estimated that, after such adjustments, the amount of investment required is \$750,000 and that the gain of \$320,000 will be reduced to \$160,000 after taxes. It will then take five years for the new equipment to pay for itself.

In some cases, additional considerations should receive further attention, such as:

—The probable actual value of the new equipment after its book value has been reduced to nothing because of the use of rapid depreciation (see Chapter IX);

—The possibility of additional gains if the new equipment increases the original plant capacity;

—The tie-up of the change in equipment with a change in price made possible by the reduction in production cost. The impact of such a change in selling price can be measured by using the methods to be now described.

C. ADAPTATION TO CHANGE IN SELLING PRICE

1. Break-Even Chart on the Dollar Base with 45° Sales Line

To illustrate the effect of price change on the break-even chart of the above type, a situation as shown in Figure 48 is referred to. In this case, a company is capable of selling \$140,000 worth of goods

each month at a selling price of \$14 per unit. With this selling price, the total monthly expenses of the business *in relation to sales* are:

$$y = \$40{,}000 + 42.8\% \text{ of sales}$$

Circumstances compel a price reduction to \$12 for each unit. Accordingly, the same quantity of goods will sell for \$120,000 and therefore

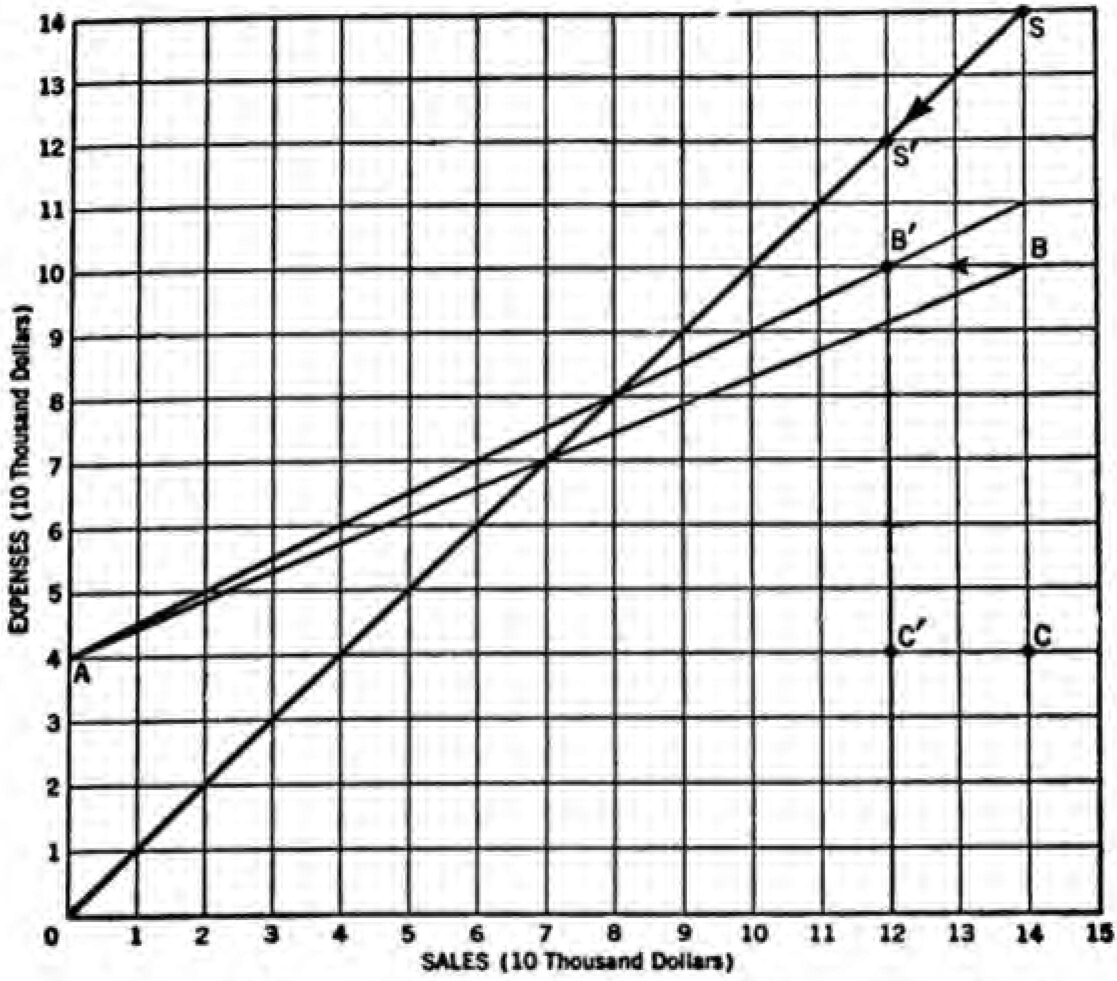

Figure 48. The Effect of Price Adjustment on the Expense Trend

the point S on the sales line of Figure 48 will move down to S′. But it will cost just as much to produce the goods; hence the expense point B will move horizontally to the left to B . The line A-B′ then becomes the trend of total expenses when the selling price of the product is reduced to \$12 per unit. The new expense trend for a selling price of \$12 per unit is:

$$y = \$40{,}000 + 50\% \text{ of sales}$$

Expressed in general terms, the new variable expense ratio resulting from price change is found as follows:

Let $p =$ percent price change
$v =$ variable total expenses for x dollar annual sales
$y =$ present expenses in relation to sales
$= a + bx$
$y' =$ expenses after price change in relation to sales
$= a + b'x'$
$= a + b' [x(1 \pm p)]$
$x =$ annual sales at present prices
$x' =$ annual sales at changed prices
$= x (1 \pm p)$

From which it appears that with price change, b becomes $b' (1 \pm p)$, which means that the new variable expense ratio caused by price change is $b' = \frac{b}{1 \pm p}$

Another approach to the determination of b′ is as follows. From Figure 48 it is found that

$$b = \frac{B\text{-}C}{A\text{-}C}$$

and

$$b' = \frac{B'\text{-}C'}{A\text{-}C'} = \frac{B\text{-}C}{A\text{-}C'}$$

accordingly

$$\begin{aligned} B\text{-}C &= b\,(A\text{-}C) \\ &= b'\,(A\text{-}C') \end{aligned}$$

whence

$$b'\,(A\text{-}C') = b\,(A\text{-}C)$$

or

$$b' = \frac{A\text{-}C}{A\text{-}C'}$$

but $A\text{-}C = x$
and $A\text{-}C' = x' = x\,(1 \pm p)$
Therefore

$$b' = \frac{b}{(1 \pm p)}$$

For example, if the trend of total expense to sales is

$$\$9{,}000{,}000 + 80\% \text{ X}$$

and there is a price reduction of 10 percent, then the trend of total expense in relation to the new and reduced income from sales X′ becomes

$$\$9{,}000{,}000 + \frac{80}{1 - 0.10} \text{ X}' = \$9{,}000{,}000 + 88.8\% \text{ X}'$$

Letting X represent the income from sales for any selling price, the prime character may be dropped.

The profit for a given income from sales is written:

$$\text{P} = \text{X}(1 - \text{b}) - \text{a}$$

At the former selling price, the profit is zero, or the break-even point occurs, when

$$\text{O} = \text{X}(1 - 0.80) - \$9{,}000{,}000$$

or

$$\text{X} = \$45{,}000{,}000$$

At the new selling price (10 percent less), the break-even point is

$$\text{O} = \text{X}(1 - 0.888) - \$9{,}000{,}000$$

or

$$\text{X} = \$80{,}000{,}000 \text{ approximately}$$

Thus, a 10 percent reduction in selling price will result in raising the break-even point of this business from \$45,000,000 to \$80,000,000. Under the old selling price, the business made a profit on sales, after \$45,000,000, of 20 percent. At \$80,000,000 sales this would amount to \$7,000,000.

A 10 percent reduction in selling price would thus wipe out this profit.

In those businesses in which the variable cost ratio (b) is high, the effect of price reduction on profits is severe.

It is also the case in such types of business, when materials anc freight costs are high and are the occasion for a high variable cost ratio, that an increase in raw materials costs or freight rates or both will have serious effects on earnings. Meat packing and fertilizer manufacture (P_2O_5) are examples of such industries. In the case of

some businesses, the unit cost may *increase* with an increase in the *volume* of sales, as in the case of a telephone company where the increment of cost of new connections may be greater than the increment of income.

2. *Break-Even Chart on a Physical Output Basis*

When the effect in change of selling price is to be recorded on the break-even chart, constructed on an output basis, as shown in Figure 45, the only alteration that need be made is to construct a new sales line with a slant according to the new unit price. The writers have found it convenient in the study of the effect of selling price on the earnings from the sale of any particular product, to construct several sales-income lines, particularly the maximum and the minimum of the range under discussion. The general principles of construction of a break-even chart with the base laid off in physical units and the ordinates in dollars are such that both the break-even point and expense trend calculations must be made in terms of both quantity and price.

For instance, the trend line of sales is

$$s = Qp$$

where s = sales
Q = quantity
p = unit price

and in which Qp takes the place of x.

The trend line of expense is

$$y = a + bx = a + bQp$$

Accordingly, the quantity at which the business will break even is that found by the equation

$$Qp = a + bQp$$

or

$$Q = \frac{a}{(1 - b)\,p}$$

Also the cost per unit of output is

$$c = \frac{y}{Q} = \frac{a + bQp}{Q} = bp + \frac{a}{Q}$$

3. *Increase in Sales Required to Balance a Specific Reduction in Selling Price*

The purpose of price reduction is usually to hold the market against competitors or to increase volume of sales through offering more attractive prices than competitors. It also makes the product available to purchasers in the lower income classes. The pricing of the product is a problem continually facing the manufacturer. The sales department, as a rule, is asking for lower prices to reduce the sales resistance. When price reductions are considered, the manufacturer is confronted with a number of problems. He may well ask himself, How much greater must the sales be to make the same profit? At what volume of sales will the business break even at the lower selling price? Can he answer these questions intelligently if he does not know the economic characteristics of his business?

Let us assume, for example, that a businessman is confronted with the suggestion that prices be cut 10 percent on the theory that it will stimulate sales and, furthermore, will bring his prices in line with those of competing products. The constant total costs of the business, let us assume, are \$250,000 per annum, and b is 0.40. The sales at present prices are assumed to be \$500,000 per annum, and hence the profit is

$$\begin{aligned} P &= X(1 - b) - a \\ &= (\$500{,}000 \cdot 0.60) - \$250{,}000 \\ &= \$50{,}000 \end{aligned}$$

What must the sales be at the reduced selling price, if the same profit is to be made? The ratio of variable total costs to corresponding sales on the basis of present prices is $b = 0.40$. If prices are reduced by 10 percent, then b becomes $0.40 \div 0.9 = 0.444$. Then the sales required to yield a profit of \$50,000 must be

$$\begin{aligned} X &= \frac{P + a}{1 - b} \\ &= \frac{\$50{,}000 + \$250{,}000}{1 - 0.444} \\ &= \$540{,}000 \text{ approximately, or 8 percent above present volume} \end{aligned}$$

If sales are not increased, the profit will be reduced to

$$\begin{aligned} P &= (\$500{,}000 \cdot 0.556) - \$250{,}000 \\ &= \$28{,}000 \text{ or a reduction of 44 percent} \end{aligned}$$

Accordingly, if the 10 percent price reduction suggested is to be justified, there must be more than a reasonable probability of a sales increase of more than 8 percent, and this probability must be weighed against the risk of a reduction in profits of 44 percent if sales are not increased after prices are lowered.

APPENDIX

The break-even chart has been applied to a large number of companies and whole industries, and at times a few interesting modifications in the general procedure have been found very helpful. The three following particular applications have been selected to illustrate some interesting cases in which the break-even chart has been adapted to situations where expenses and incomes have particular characteristics.

1. THE BREAK-EVEN CHART IN THE NATURAL GAS BUSINESS

It may be found more convenient at times to rearrange the cost lines in the chart by placing the variable total cost lines at the bottom of the chart and the constant total cost lines immediately above. That arrangement is used in the following example quoted from the *Gas Age Record* of March 17, 1934.* This case also illustrates a situation in which the sales line reflects quantity pricing.

> The recent increase in business activity has also affected the natural gas industry, resulting in augmented profits, or in some cases, decreased losses in the major operating divisions of the industry. Natural gas wells, pipe-lines, and other structures and equipment which were operated at low use factors at a small profit or loss, are now operated at higher use factors or flows. Their profits have been increased or their losses decreased.
>
> It is then of great interest to the executive in the natural gas industry to know what annual or ultimate production a gas well must deliver or at what use factor a pipe-line must be operated in order to be profitable. The profits at a certain use factor or production are usually known, but the use factor or flow at which operations become profitable is not always accurately calculated or estimated.
>
> The break-even chart, as developed by Professor Walter Rautenstrauch of Columbia University, is a graphical representation of revenues, costs, and profits or losses at various use factors, flows, deliveries, etc. Once constructed it shows at a glance the profits or losses of a natural gas well, a pipe-line, etc., at various deliveries, and also the flow or use factor at which no profits are made but also no losses are incurred, the so-called "break-even point." In addition it shows graphically the effect of changes in revenues or fixed and variable operating costs on profits or losses at

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certain deliveries. The break-even chart has been applied to many businesses and industries, but some of its application to the natural gas industry have not as yet to the author's knowledge been published.

The construction of the chart is simple. On the horizontal scale or abscissa are laid off the use factors, deliveries, etc., of the pipe-line, gas well, or other structure which is being studied. On the vertical scale or ordinate are measured the fixed and variable operating costs incurred and the revenues derived at various use factors, deliveries, etc.

The following examples show the application of the break-even chart to hypothetical gas wells and a hypothetical pipe-line. There are, of course, many other applications of the chart in the natural gas industry. The examples below serve only to illustrate the construction and use of the break-even chart.

The following data are available as to gas wells:

Average drilling cost, including dry hole allowance and leasing expense	\$8,000
Annual interest rate on investment	6%
Annual operating and overhead costs per well	\$500
Annual royalty	⅛ of gross revenue
Estimated ultimate natural gas reserves per well	Varying from 20,000 MCF to 270,000 MCF
Estimated productive life of average gas well	10 years
Price of gas at well per MCF	15¢
Discount factor applied to future revenue and costs	0.70

From these data the following table can be constructed:

Estimated ultimate natural gas reserves in MCF	20,000	120,000	170,000	270,000
Gross revenue in dollars	3,000	18,000	25,500	40,500
Present worth of gross revenue in dollars	2,100	12,600	17,900	28,350
Cost of well in dollars	8,000	8,000	8,000	8,000
Present worth of interest on investment in dollars	3,360	3,360	3,360	3,360
Present worth of royalty in dollars	260	1,580	2,240	3,540
Present worth of operating and overhead costs in dollars	3,500	3,500	3,500	3,500
Present worth of all costs in dollars	15 120	16,440	17,100	18,400
Present worth of profit or loss in dollars	13,020 (*loss*)	3,840 (*loss*)	800	9,950

The break-even chart based on this tabulation is shown in Figure 49. It will be seen that, based on the above assumptions, wells whose estimated reserves are less than the approximately 160,000 MCF are unprofitable. This example illustrates the application of the break-even chart principle to natural gas wells the productivity of which is, of course, not

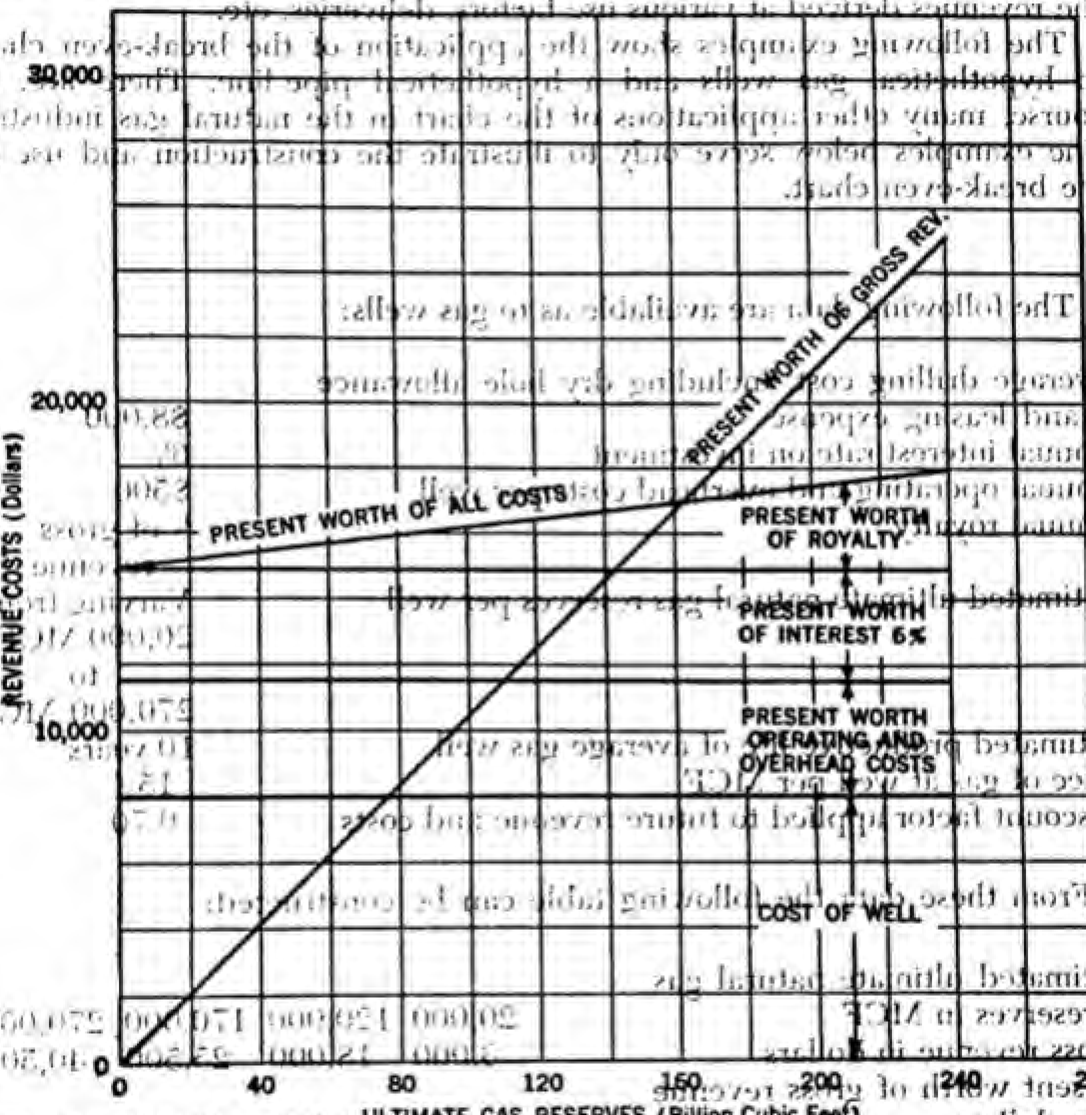

Figure 49. The Break-even Chart of a Natural Gas Well

controlled by the owners of the wells. On the other hand, the owners may be able to decrease their fixed and variable costs. If, for example, the annual interest rate on the investment is taken as 4 percent and annual operating and overhead costs are reduced to $300 per well per year, gas wells whose estimated reserves are in excess of 130,000 MCF become profitable. It should be noted that the chart, as constructed, is valued only for wells which are being operated. Dry wells are not considered.

On a pipe-line not only fixed and variable costs but also gross revenue may be controlled to some extent. This is shown in Figure 48, which represents the break-even chart of a hypothetical long-distance natural gas pipe-line. The investment required for this line, which was assumed to have a length of 500 miles, an outside diameter of 24 inches, and a maximum daily capacity of 145 million cubic feet per day, was estimated to be $15,450,000. It was also assumed that gas could be purchased by the pipe-line for resale at a price of 5¢ per MCF and that gas could be sold at the terminal of the pipe-line at prices varying from 22¢ to 8¢ per MCF, the highest price gas being sold first, gas of the next highest price next, and so on. The following tabulation is based on these and other data.

Pipe-line annual use factor in percent	20	50	70	90
Per year in thousands of dollars:				
Gross revenue	2,320.6	4,693.9	5,957.7	7,014.5
Cost of gas for resale	527.0	1,317.5	1,844.5	2,371.5
Cost of compressing station fuel	46.8	117.1	163.9	210.8
Compressing station operating costs	252.8	252.8	252.8	252.8
Pipe-line operating costs	185.0	185.0	185.0	185.0
Fixed management and overhead costs	571.6	571.6	571.6	571.6
Return on investment (8 percent)	1,236.0	1,236.0	1,236.0	1,236.0
Amortization (6 percent, 15 years)	664.4	664.4	664.4	664.4
All costs	3,483.6	4,344.4	4,918.2	5,492.1
Profit or loss	1,163.0 (*loss*)	349.5	1,039.5	1,522.4

The break-even chart (Figure 50) representing the above tabulation graphically indicates that the break-even point of the pipe-line occurs at about 43 percent of capacity. If the return on the investment is lowered—in other words, if the pipe-line can be financed at lower interest and dividend rates than an over-all return on the investment of 8 percent—the break-even point becomes a lower percentage of the capacity. An increase in the price of gas sold at the terminal of the pipe-line will also lower the break-even point. The effect of these changes is indicated in Figure 48.

The break-even chart can, of course, also be applied when additional investments are made. For example, additional compressing station or looping may be necessary to increase the capacity of a pipe-line. A graphical comparison of increased revenues but also increased costs with revenues and costs before additional investments will be very valuable.

There are, as stated above, many other applications of the break-even chart. The above examples illustrate only the usefulness of the chart as an executive tool in the natural gas industry.

2. THE BREAK-EVEN CHART APPLIED TO A SILK MILL

In some cases, as previously stated, the straight-line relationship between certain types of expenses to output does not hold throughout the entire range of output. This is sometimes the case in the process industries in which certain types of cost vary directly with output from about 30 percent to 100 percent of capacity. Below 30 percent capacity, due to the nature of these costs, there is a downward trend. Such a case is reported in the following example from practice.

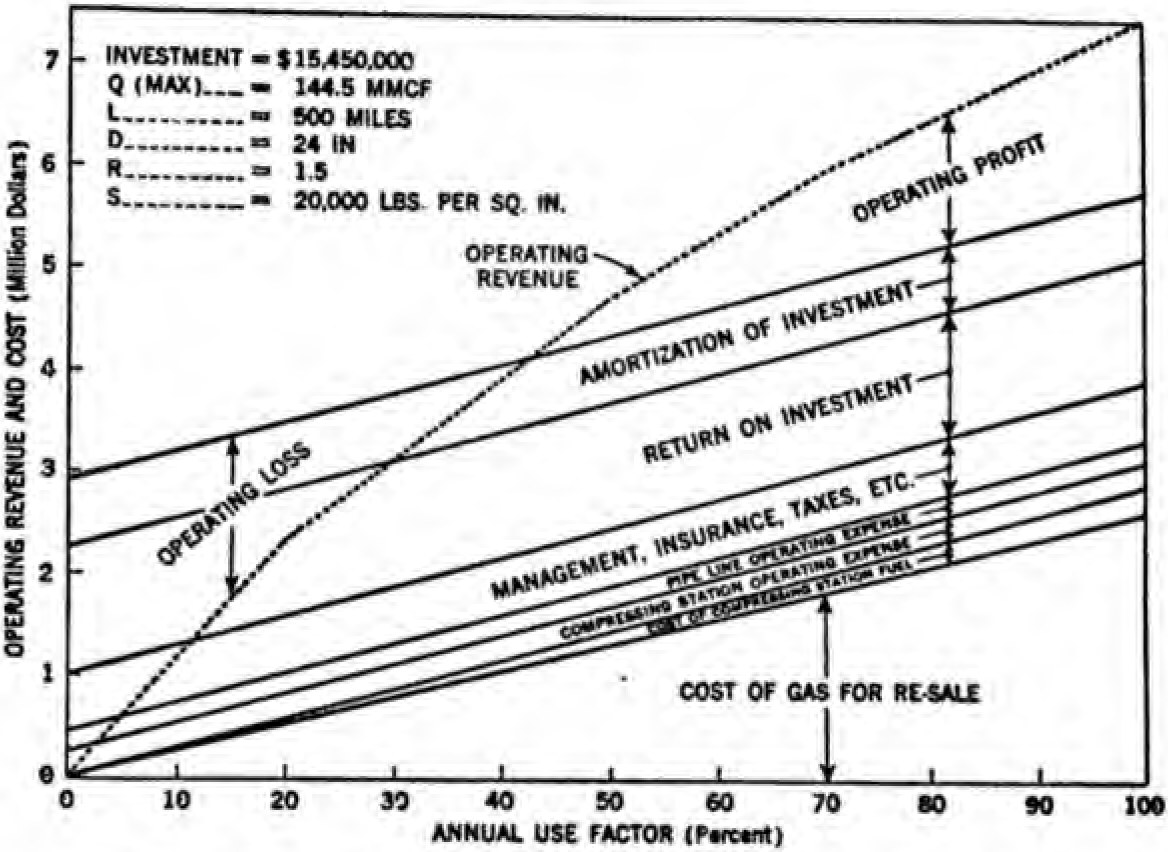

Figure 50. The Break-even Chart of a Natural Gas Pipe-Line

Mr. H. R. Mallory, of Cheney Brothers, South Manchester, Connecticut, in *Mechanical Engineering*, August, 1933, presents an example of the use of the break-even chart in the silk industry. He states in part as follows:

> It has been demonstrated in actual practice that it is possible to control these expenses * in direct proportion to plant activity (allowance being made for fluctuations in raw-material market prices). Various ways and means of doing this are used in the items of variable manufacturing overhead in the same manner; therefore some method must be devised, that will enable us to set limits of variation from the straight-line relationship, so it may be used for budget and control purposes. Deviations

* Direct materials and direct labor.

from the straight-line relationship for indirect expenses are caused by the necessity of running elevators, oiling shaftings, repairing belts, main motors, switches, etc., even though some of the machines which are serviced by them may be idle due to reduced volume of business.

Mill Allowances for Control of Departmental Room Variable Expense

Let us assume that the plant is divided into many departments or areas of expense control and that over each department is a foreman who controls, in addition to direct labor and direct material, the following items of expense: (a) indirect labor, (b) power, (c) indirect supplies, (d) machine repairs, and (e) miscellaneous expense.

If we consider one room in which there are, for instance, 400 machines, it is possible to establish with accuracy, after careful study, the amount of indirect labor required when all of the machines are in operation. Similarly, it is possible to establish the required amount of expense for power, indirect supplies, machine repairs, and miscellaneous expense. The readings in dollars at 100 percent activity in Figure 49 represents the controllable indirect variable expenses required when the room is running at full activity. The scale of the chart has been set so as to provide the readings in terms of expense per week, instead of annual expense.

The readings in Figure 51 should be made from the base line up to the line of expense in question. In the preceding charts, the expenses were added, one to the other. On either form of chart, a straight line, passing through O and representing a variable expense, is directly proportional to plant activity or income from sales.

The items of indirect expense listed in Figure 51 should, according to the sales dollar, vary in direct proportion to activity, but physically it is impossible to make them do so, and therefore limits to the amount of variation from the theoretical ideal should be established. At Cheney Brothers, South Manchester, Connecticut, budgets for 100, 80, 60, 40, 20, and 0 percent activity were established for each department in the plant. By a careful comparison of actual expenses with the budgeted allowances and by charting the amount of actual expense for the various departments over a period of about two years, it became possible to establish maximum and minimum limits of variation from the straight-line relationship for the variable indirect expenses. It is obvious that the minimum variation from the directly proportional straight line for various degrees of activity is zero, so that the straight line itself may represent the minimum. Empirically, it has become possible to state that the maximum is the parabola expressed by the equation $Y^2 = KX$ (see Figure 51).

In Figure 51, the distance between the minimum straight line and the maximum parabola is called D. Somewhere between the minimum and maximum is the permissible allowed variation over and above the straight line. This permissible allowed variation is expressed in terms of percentages of D. For instance, the allowed variation from the minimum theoretical straight line for indirect labor is 40 percent of D, and a curve

plotted through points of 40 percent of D for different percentages of activity represents the expense control curve for this item. For any given weekly activity, the ordinate to the expense control curve represents the standard allowed expense with which the actual for the week is compared. Each foreman is thus furnished with expense reports each week for the item of variable indirect expense he controls, and he must keep

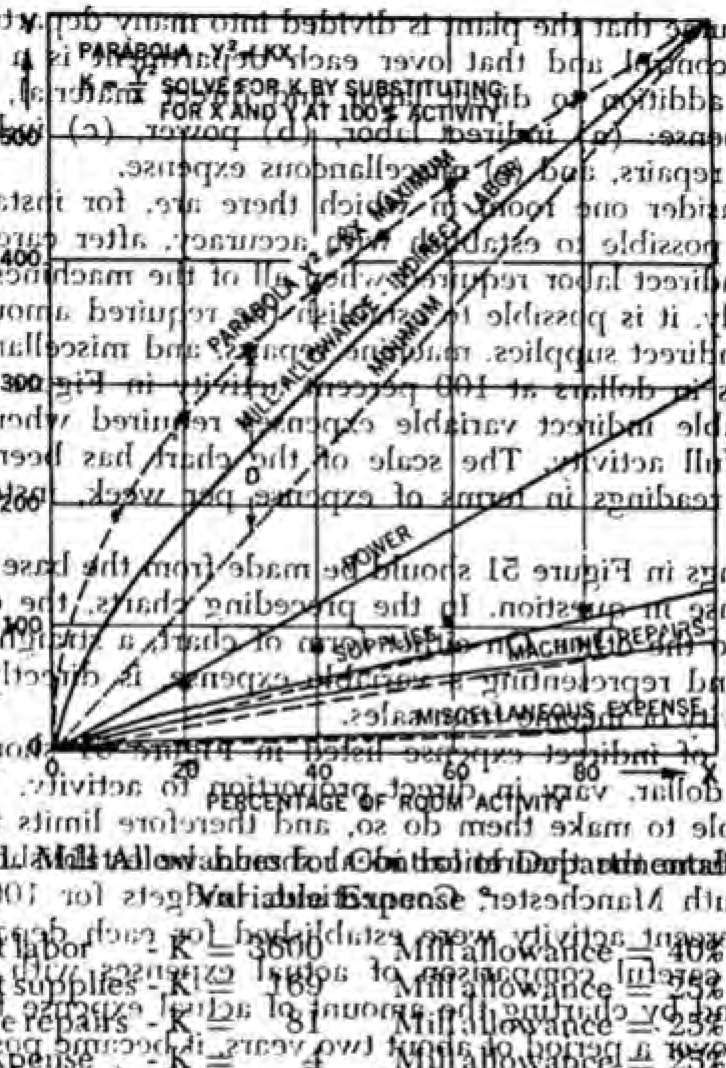

Figure 51. Mill Allowances for Control of Departmental Room Variable Expense

Indirect labor	- K = 3600	Mill allowance = 40% of D
Indirect supplies	- K = 169	Mill allowance = 25% of D
Machine repairs	- K = 81	Mill allowance = 25% of D
Misc. expense	- K = 4	Mill allowance = 25% of D

his expense within the prescribed limits. [illegible]

It has been possible to apply the standard allowance of 25 percent of D, for machine repairs, indirect supplies, and miscellaneous expense in practically all production departments. The mill allowance for indirect labor, however, while set at 40 percent of D in most departments, varies according to local conditions [illegible] percent of D in some cases.

* Variable power mill allowance is straight line. Fixed expense of power plant is [illegible]

but in no case is it allowed to exceed 100 percent of D, which is the parabola. So far, it has not been possible to determine the allowed variation for variable power for the reason that individual departmental meters have not been available.

Variation of Fixed Expenses with Activity

There are certain items of "fixed expense" which Professor Rautenstrauch refers to as "constant total costs." According to the control required by the sales dollar, all expenses whether classified as fixed or variable, should vary in direct proportion to plant activity. It may readily be seen that the amount of loss due to operating below the break-even point is entirely due to the so-called fixed expenses remaining constant for all degrees of activity. For this reason, it is necessary to examine the whole group of fixed expenses in order to determine which of them may in reality be "semi-fixed."

There are relatively few items of expense which cannot be made to vary to some extent with activity. There are some expenses, such as insurance, taxes, rentals of properties where properties are leased, etc., that will not vary with changes in activity and are actually fixed per annum. Such expenses as salaries, stores expense costing, central planning, etc., while in many instances classified as fixed, may actually be made to

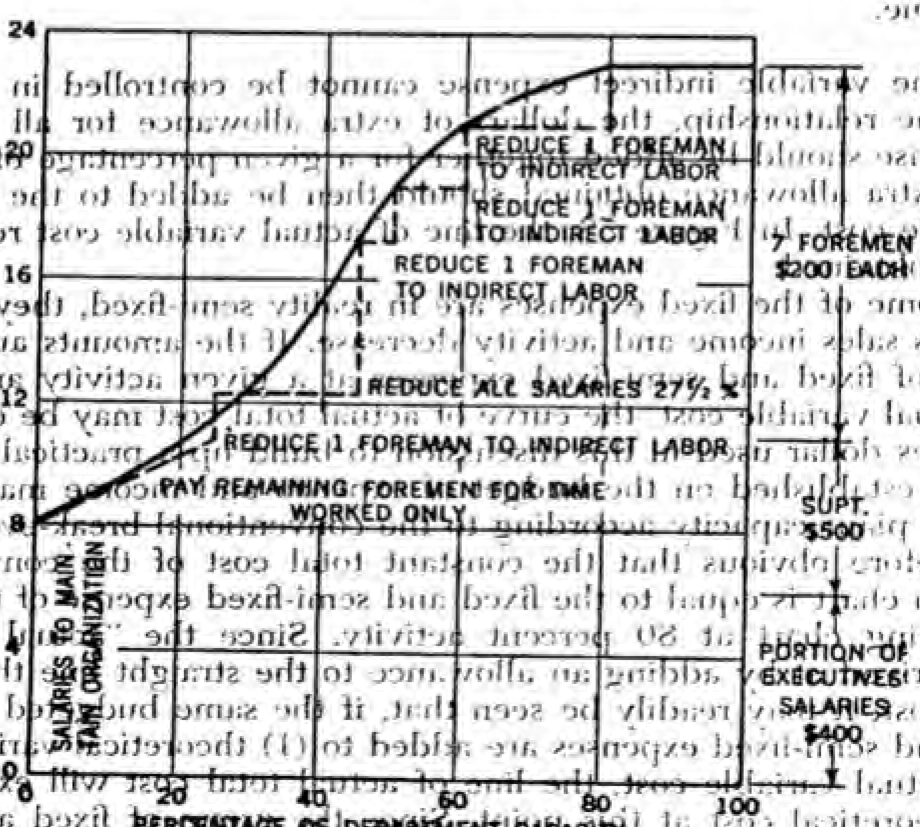

Figure 52. Control of Salaries of Production Department Showing Method of Control for Semi-fixed Expense

vary to some extent with activity. Figure 52 is a sample chart illustrating the way one of the so-called fixed expenses may be made to vary with activity. At first glance it may appear to be a very unsatisfactory method of treating salaried employees. On the other hand, it is important to realize the economic justification for the payment of salaries and to control them in a manner that is humane, as well as preserving the best nucleus of an organization for the future, for quite often a failure to plan a method of salary control results in the sudden discharge of a large number of salaried employees with no advance warning. This, however, is a subject in itself, and the chart serves to illustrate one method of controlling a so-called fixed expense and making it vary with activity.

The Modified Break-Even Chart

The conventional break-even chart is based on the assumption that all variable expense has a straight-line relationship or is in direct proportion to activity, and that all the items classed as fixed expense remain as constant fixed expense for the whole range of plant activity.

In Figure 53 the conventional break-even chart is designated by the following lines:

a. Theoretical variable cost (dotted line).
b. Theoretical total cost (dotted line).
c. Income.

Since the variable indirect expense cannot be controlled in a direct straight-line relationship, the dollars of extra allowance for all items of such expense should be added together for a given percentage of activity and the extra allowance obtained should then be added to the theoretical variable cost. In Figure 53, the line of actual variable cost represents the result obtained.

Since some of the fixed expenses are in reality semi-fixed, they may be reduced as sales income and activity decrease. If the amounts authorized for items of fixed and semi-fixed expenses at a given activity are added to the actual variable cost, the curve of actual total cost may be obtained.

The sales dollar used in this discussion to build up a practical working chart was established on the budget of expense and income made at 80 percent of plant capacity according to the conventional break-even chart. It is therefore obvious that the constant total cost of the conventional break-even chart is equal to the fixed and semi-fixed expense of the practical working chart at 80 percent activity. Since the "actual variable cost" is arrived at by adding an allowance to the straight line theoretical variable cost, it may readily be seen that, if the same budgeted amounts of fixed and semi-fixed expenses are added to (1) theoretical variable cost and (2) actual variable cost, the line of actual total cost will exceed the line of theoretical cost at this point. Since the group of fixed and semi-fixed expenses contains some semi-variable elements that may be made to decrease as activity decreases, these same semi-variable elements increase as activity increases, although not in direct proportion to activity. In

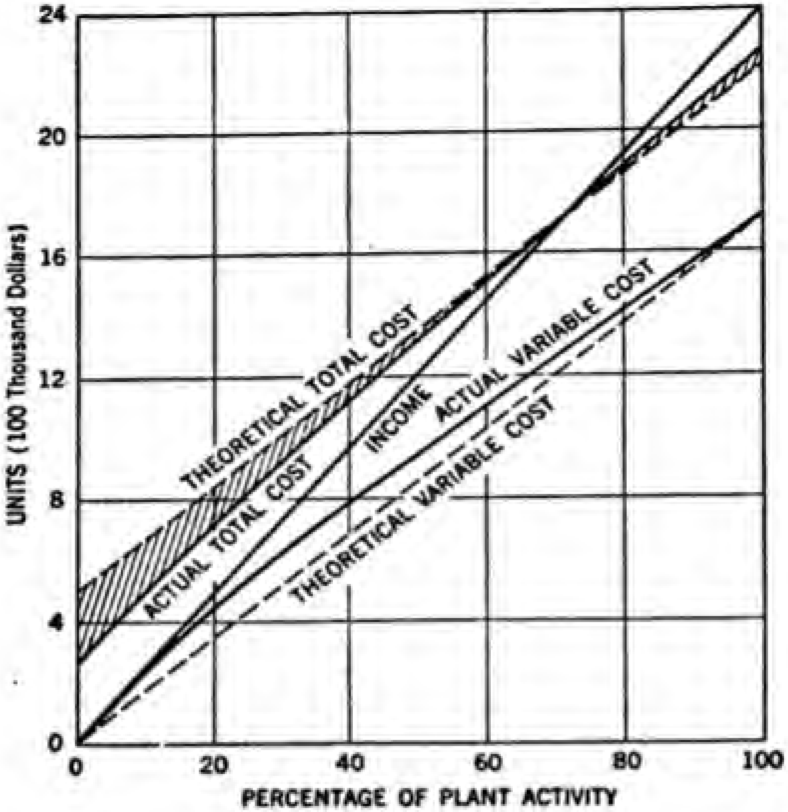

Figure 53. Comparison of Practical Working Chart with Theoretical Crossover Chart

Figure 53, the line of actual total cost is shown crossing the line of theoretical total cost at some point above the break-even point and gradually increasing as activity increases.

The cross-hatched area of Figure 53 represents the difference between the theoretical break-even chart and a practical working chart. For example:

At 90 percent activity, Professor Rautenstrauch's equation $p = X - (a + bx)$ gives a profit of $130,000. In the equation

p = profit
a = fixed expense, or, as Professor Rautenstrauch designates it, "constant total costs"

$$b = \frac{\text{variable total costs}}{\text{corresponding sales}}$$

Based on a curve reading of the actual total cost and the income line in Figure 53, the profit at 90 percent activity is reduced approximately $40,000 by the cross-hatched area, or instead of $130,000, the profit is $90,000.

Similarly, at 30 percent activity, the same equation indicates a loss of $290,000.

Taking the difference between the income line and the actual total cost,

there is a reduction in the loss, according to the cross-hatched area, of approximately $95,000.

From this comparison, it may be seen that a literal use of the equation is likely to be misleading. This should not detract, however, from the value of the underlying theory expressed by the equations, for an understanding of the laws developed by Professor Rautenstrauch is essential in order properly to control any industry. Each business has its own peculiar economic characteristics and these should be developed and expressed in such a manner that the theoretical chart may be modified and put on a practical working basis.

The following special economic characteristics develop from a study of the curves:

(1) Direct labor and direct materials should vary in direct proportion to the percentage of plant capacity in a straight-line relationship.

(2) Variable overhead items should be made to vary with activity as closely as possible to the straight-line relationships.

In the silk industry, the variable overhead items may be controlled between the maximum and minimum limits shown in Figure 51, and according to the equation

$$Y = p\,(\sqrt{KX} - bX) + bX$$

where p is the percentage of D allowed. The curve for which this equation is the expression may be developed as outlined in the caption of Figure 49. It is felt that it is better to develop the curve in terms of percentage of D (see Figure 49) as there is a certain comparative value in saying that in one room the extra allowance for indirect labor is 40 percent of D, whereas in another it may be that 30 percent, or 40 percent of D, if it can be accomplished, results in a saving. This is of great importance in a fashion industry, where activity is likely to fluctuate rapidly.

The value of p or percentage of D is a special economic characteristic for each room or burden center, and for each class of variable indirect expense.

Whether the variable allowances described will apply to industries other than the silk industry is not definitely known, although the general characteristics of the expense class should be similar.

(3) The fixed expenses should be carefully examined in order to determine how and to what extent they may be made to vary with activity. Variable budgets should then be charted in order to determine the special economic characteristics of the items of fixed expense. When this has been done, the break-even chart may be modified to suit the particular business.

(4) The modified break-even chart constitutes a variable budget. As labor rates change and methods are improved, costs change, so that the chart should be revised at least twice a year at six-month intervals and more frequently if necessary. During the period of time for which the chart is effective, the relationship between expense, income, and activity

should be shown on the modified break-even chart, provided the average of selling prices remains the same. When the average of selling prices is changed, it is a simple matter to superimpose a new income line on the break-even chart.

(5) If it is assumed that the capital employed in the business shown in the accompanying charts is turned over twice a year, the percentage of profit on the capital employed will be double the percentage of profit on sales shown in the normal sales dollar; in other words, instead of a 3.3 percent profit, there is a 6.6 percent profit on the capital employed. It is apparent that the economic characteristics of the business shown on the accompanying charts are unsatisfactory, and therein lies the value of the break-even chart, for it discloses an inadequate profit at normal activity and a break-even point at a relatively high activity, which would mean that losses would occur with a slight drop in volume of sales. When it is stated that a 6.6 percent profit on the capital employed is an inadequate profit, it must be remembered that Federal taxes, interest on borrowed money, appropriations for betterments, provision of part of the surplus for pensions, etc., as well as preferred and common stock dividends, all have to come out of the profit referred to.

Importance of the Break-Even Chart

In closing, it is desired to point out that the special economic characteristics referred to apply to a single industrial organization that is a part of an industry. From the point of view of the individual organization, we have learned in recent years that the fixed quarterly, semiannual, or annual budget is not flexible enough to insure proper control of expense, or else that we are not endowed with sufficient prophetic vision to enable us to forecast the volume of business to be realized, on which to base the budget. Economic necessity has driven the individual organization to look for a more flexible medium of expense control. It is assumed that readers will appreciate that the major portion of the expenses subject to control consists of the wages of men. We are, therefore, forced to contribute to human misery by dropping men from the payroll when sales volume falls. Anything that may be done to eliminate fluctuations in activity is, therefore, of decided benefit to the industrial worker. Since the laws developed by Professor Rautenstrauch may be applied to industry in the aggregate as well as to the individual organization, we may reasonably hope that an appreciation of these laws on the part of those who control the many organizations in an industry and on the part of those who finance industry may lead to more stable conditions of production.

QUESTION: If the author of this paper had included the variable expenses arising from the special conditions discussed under the heading Special Economic Characteristics in his calculations for determining the total controlled costs, would he not have had an approximate straight-line relation between total expense and income over the major operating range of his business? Examine Figure 49 and find the range of operations over which the total expenses closely follow an approximate straight-line trend.

3. MULTIPLE-PRICE POLICY IN THE RADIO MANUFACTURING INDUSTRY

Mr. Robert J. Levine,* in his master's essay entitled "A Study of the Small Radio Manufacturing Industry," makes the following observation.

> During the past ten years the writer, in watching the pattern of radio retail prices, has noticed a sales pattern which indicates that a rather unique price policy has been developed by some of the smaller companies in the industry. Radio pricing in this field is done two ways. The large companies set a price which satisfies a certain demand derived from their forecast of sales and then depend for sales on pressure advertising. Because of the cost of this heavy advertising, radios made by the larger companies usually cost more than those made by the smaller companies which do not have the means for following such a program. The smaller companies however have to compete on a price basis alone and are for this reason among others highly conscious of costs. The first step in marketing followed by the smaller companies is direct selling to the dealer and thus eliminating the jobber.
>
> The second step in offering a new line of radios is to offer their output in three price stages, which are an introductory stage, a quantity stage, and a closing-out stage. A pricing policy of this type gives rise to a new approach to the break-even chart.

Mr. Levine states that the dealer, knowing that the first price offered, which is the highest of the series, will later be reduced, makes an initial purchase sufficient to satisfy the first demand. After this demand declines, business is then stimulated by offer of the merchandise at a lower price. Toward the end of the season, the manufacturer practically dumps his remaining inventory on the market at cost. The break-even chart serves a very convenient use in setting up this multi-price policy. To illustrate the new method of pricing, the following example is used.

THE ONE-PRICE METHOD

A manufacturer proposes to produce 50,000 radios in the year to sell to the consumer for \$17.50 each. The manufacturer, under present practice, sells the dealer at 60 percent of consumer price or at \$10.50 each. The total sales, if all sets are sold at the above price, will amount to \$525,000. Using the data of seven leading radio manufacturers, a business of this proportion should experience total annual expenses of approximately \$30,000 + 0.87% of sales. The break-even chart of the company when following the single-price policy should be as shown by the full lines in Figure 54. Under the single-price policy the manufacturer would break even at

$$Qp = \frac{a}{1 - b}$$

* Graduate student, Department of Industrial Engineering, Columbia University, 1948.

where Q = quantity
p = price per unit

then

$$Q \cdot 10.50 = \frac{30{,}000}{1 - 0.87}$$

when

$Q = 22{,}000$, approximately.

The manufacturer's profit on the sale of the entire 50,000 radio sets would be

$$P = 50{,}000 \cdot 10.5\,(1 - 0.87) - \$30{,}000 = \$38{,}250$$

THE MULTI-PRICE METHOD

Under the multi-price method, the manufacturer sets a price which will result in a break-even point at say 20 percent of total output and which will also be the price at which say 30 percent of the total output is sold. In terms of radio sets, the break-even point would be at 10,000 sets and the first price would hold for 15,000 sets.

(1) *The First Price.* The price at which the manufacturer would break even at 10,000 sets is found as follows.

By calculation

The break-even chart of Figure 54 is laid out such that the variable total expenses for 50,000 radio sets is 87 percent of $\$525{,}000 = \$456{,}750$ or \$9.135 per set. For 10,000 sets, the total expenses of manufacture would be

$$\$30{,}000 + \$9.135\,(10{,}000) \text{ or } \$121{,}350$$

If the business is to break even at 10,000 sets, the price per set must be \$12.135. This means that if the consumer's price is based on a mark-up of 40 percent, the consumer's price will be $\dfrac{\$12.135}{.60} = \$20.22$, say \$20.25.

The sales of the manufacturer for the first 15,000 sets (30 percent of output) will be $12.135 \cdot 15{,}000 = \$182{,}025$ and his profits on these sales will be

$$P = 15{,}000(\$12.125 - \$9.135) - \$30{,}000 = \$15{,}000$$

By chart

The above information may be quickly derived from the data obtained from Figure 54 through drawing the sales line O-C such that it crosses the expense line at 10,000 sets and terminates at C at 15,000 sets. The chart, of course, must be large in angle so that the dollar sales required to break even (\$121,350) and the total sales value of the 15,000 sets (\$182,025) can be read from the chart with close approximation.

(2) *The Second Price.* The second pricing is determined as follows. Depending on the market, particularly how well the public is buying in the different price ranges, it may be decided that the next 30,000 sets which would bring the total sales up to 90 percent of output, are to be sold at a price which will yield a profit for 90 percent of the output equal to what

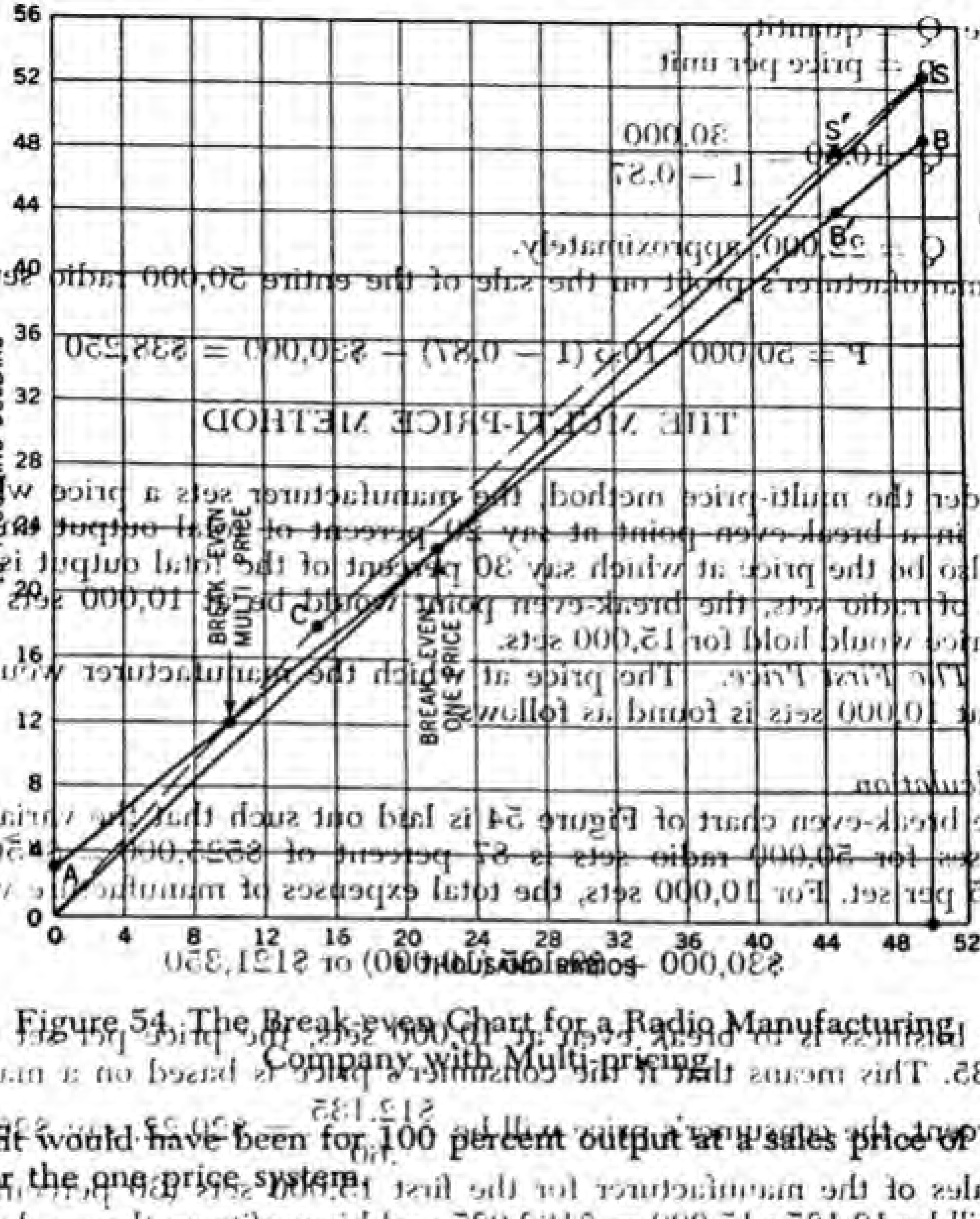

Figure 54. The Break-even Chart for a Radio Manufacturing Company with Multi-pricing

the profit would have been for 100 percent output at a sales price of $10.50 as under the one price system.

By calculation

The cost of 45,000 sets is

$$
\begin{aligned}
c &= \$30{,}000 + (9.135 \cdot 45{,}000) \\
&= \$441{,}075
\end{aligned}
$$

The profit to be realized is $38,250 as determined above. Hence the cumulative sales income for the 15,000 sets sold at the first price and the 30,000 sets now to be sold at a price to be determined, is

$$\$441{,}075 + \$38{,}250 = \$479{,}325$$

But the first lot of 15,000 was sold for $182,025 as determined above and therefore the second lot of 30,000 sets is to be sold for

$$\$479{,}325 - \$182{,}025 = \$297{,}300$$

or for \$9.91 per set. On the basis of a 40 percent mark-up, the consumer price would be \$16.50.

By chart

An ordinate is erected at 45 on the base. Where it cuts the expense trend line A-B, mark that point B′. Lay off B′-S′ = B-S and join C and S′ to show the sales line for the second lot (30,000 sets). The vertical distance of horizontals through C and through S′ divided by 30,000 determines the price to the dealer of the second lot.

(3) *The Third Price.* The remaining 5,000 sets are then dumped on the market at a price to the dealer equal to the unit cost of the whole lot of 50,000 sets. The price to the dealer will then be

$$\frac{30{,}000 + (50{,}000 \cdot \$9.135)}{50{,}000}$$

or \$9.735 per set.

The consumer's price will be $\frac{\$9.735}{0.60} = \$16{,}225$, say \$16.25

The line S′-S completes this chart.

In summary then: Under the one-price system, the price to the dealer is \$10.50 per set, while under the multi-price system the first lot of 15,000 sets is sold for \$12.135, the second lot of 30,000 sets is sold for \$9.91 per set, and the remainder is sold for cost at \$9.735 per set. This practice is not looked upon with favor by the large manufacturer, nor by the majority of the dealers, because as one prominent member of the radio industry recently stated at a meeting of the National Electrical Retailers Association:

> Dealers expect from manufacturers price stability to make their inventories safe investments and prefer to deal with producers who follow a sound and equitable program of dealer franchising.

PART II

INDUSTRIAL COST CHARACTERISTICS

INTRODUCTION

THE ECONOMIC CHARACTERistics of a business as a whole, which was developed in Part I, may be likened to the functional characteristics of a machine or the structural characteristics of a bridge or building. The machine designer in developing a new machine proceeds to lay out the whole mechanism according to the functions it must perform. The whole arrangement of the many parts is laid out according to a general pattern which experience has shown will accomplish the over-all requirements of the intended operations. The completed machine when tested is found to have certain characteristics of performance which, if the design is well conceived, will closely parallel the results which the designer sought to attain. But after the general lay-out with respect to functional operation has been made, the designer must then proceed to determine for each part the proportions needed to provide adequate strength and stiffness. Unless the parts are properly proportioned the machine will not work, even though the general pattern of its lay-out

may be functionally sound. If also the structural designer may conceive of a bridge which is functionally adapted to its intended use but if its members are not correctly proportioned, the bridge will fail. So also in business enterprise, the general character of its financial and operational organization may be well conceived, but if the methods for finding and estimating detailed operational costs are faulty, the enterprise may fail. Functionally, the business may be well conceived as to markets for its products, methods of production, sources of raw materials, and financial structure, but if the instruments on which it relies to guide its course are faulty and do not reflect correctly the details of its economic performance the business is in danger.

Accordingly, while it is necessary that the businessman understand the over-all operating characteristics of the business he is managing, he must also understand fully the details from which the over-all facts are derived or else he will not be in a position to make the adjustments necessary to adapt the business to the ever-changing economic environment of the modern world.

Part II of this book is therefore devoted to an examination of the principles underlying the detailed costs of production and of the methods which experience has proved are best adapted to embodying these principles in practical operative procedures. To develop the principles and methods for determining the cost of the product as it is built up from raw materials through the many steps of production to delivery to the customer is the primary objective of this part of the book. Another objective is the development of the principles and methods of the many kinds of cost calculations that are needed for making the innumerable decisions demanded of management at all levels of operation.

VIII

BASIC CALCULATIONS IN THE USE OF MONEY

ENGINEERS AND INDUSTRIALists use machinery and equipment to create goods and services. The machinery and equipment used are recorded in books of account as "worth" specific amounts of money, and the goods and services produced are stated to have "cost" this or that amount of money. When new and improved machinery is offered the manufacturer, he wants to know whether it will pay to buy it at the price offered. The price paid for machinery and equipment, and its relation to the costs of goods and services produced by their use, poses a problem in the investment of money.

More specifically, the problem of investment in machinery and equipment is a problem in alternatives; will it pay to buy A at Price X, or B at Price Y or C at Price Z *for use under specific circumstances.* The "use under specific circumstances" is a very important part of the problem of investment to which more attention will be given as our study proceeds.

A. THE EARNING POTENTIAL OF MONEY

Before the question, will it pay, can be answered, it will be necessary to acquire some basic concepts about money, particularly about what may be termed its earning potential and its time value. It is frequently stated that money is a medium of exchange. When money is paid in exchange for materials, machinery or services, the amounts so paid are recorded in books of account and become known as the "book values" of the items purchased.

Money not only gives one the capacity to possess or to acquire something when used as a medium of exchange but it also has the capacity to earn, that is, it has a rental value. The rental value of money is expressed in terms of interest rates.

Money is rented or loaned at rates of interest which depend on the state of the money market and on other considerations such as the allowable legal rates which vary in the different States of the Union. Money is rented or loaned to the Government, or to a corporation, when one buys their bonds and notes. Using money to buy bonds and notes or to deposit in savings accounts in banks for the purpose of earning more money are well-known procedures by which investors endeavor to increase their money.

The earning potential of money has an important bearing on the problem of investing in a new Machine A to use in a manufacturing process and to replace a present Machine B used for the same purpose. If it is determined, for example, that by using Machine A to replace Machine B an annual saving of $1,000 is probable, the "pay-off" is not only in the annual savings of $1,000 per year but also in *the earning power of each annual saving* throughout the estimated useful life of the machine. If, for example, the useful life of the machine is estimated to be 10 years, the total savings incurred in its use are not only $1,000 for each of its 10 years of use, or $10,000 in total, but there are in addition the potential earnings in the form of interest (compounded annually) for 9 years on the first year's savings, for 8 years on the second year's savings, for one year on the ninth year's savings. If the interest rate used is 4 percent, then the earnings on the annual savings will, in this example, amount to $2,007. These earnings on the savings, together with the savings themselves, will therefore total $12,007. The thoughtful student, examining critically the estimate made above, will ask himself: How is it determined that the useful life of a machine is 10 years or any other number of years? Why is 4 percent interest used in the example, and will it probably

be the same for the estimated 10 years? Does a manufacturer really put such savings as determined in this case at interest or are they intermingled with all the assets and used in the business? Upon what assumptions are the savings of $1,000 per year made? What is the probable error of estimate?

These are important questions, and some satisfactory answer must be given if economic calculations of the above nature are to make sense. With these questions held in abeyance for the time being and, in order to consider them more fully in relation to other problems in engineering economics, the basic formulas used in making calculations of the above nature will now be reviewed.

B. SIMPLE INTEREST

This is the form of interest which applies to the original sum or principal only. Thus, if

$$P = \text{the principal or sum of interest}$$
$$R = \text{the rate of interest (usually annual)}$$

then the total amount of the interest at the end of the first stated time period (usually one year) is PR, at the end of the second period is 2 PR, and at the end of the Nth period is NPR. Thus, if $100 is put at 6 percent annual simple interest, it will have a value after 6 years of

$$\$100 + 6\,(\$100 \cdot 0.06) = \$136.$$

The value of a principal sum at interest after a period of time is known as the *amount* and may be designated by A. Therefore, if

$$P = \text{the principal (the original sum put at interest)}$$
$$R = \text{the rate of interest (annual)}$$
$$N = \text{the number of years}$$
$$A = \text{the amount (principal plus interest)}$$
$$I_s = \text{the interest,}$$

then

$$A = P\,(1 + NR)$$
$$I_s = PNR$$

The following problems illustrate the use of these formulas.

Problem 1. What will be the amount, that is, the value of $150, after 3 years at 6 percent simple interest?

$$A = \$150\,(1 + 3 \cdot 0.06)$$
$$= \$150 \cdot 1.18 = \$177$$

Problem 2. What sum (principal) invested at 5 percent simple interest will amount to \$600 in 4 years?

$$\$600 = P(1 + 4 \cdot 0.05)$$
$$P = \frac{\$600}{1.2} = \$500$$

Problem 3. What is the simple interest on \$700 for 4 years at 6 percent?

$$I_s = \$700 \cdot 4 \cdot 0.06$$
$$= \$168$$

If interest payments are due and paid annually, then only simple interest can apply.

C. COMPOUND INTEREST

When a sum of money is put at interest, which is payable at stated periods, and the interest when due is added to the principal and also bears interest, the sum is said to be at compound interest. The total amount accumulated after a given time is termed the *compounded amount*. The difference between the compounded amount and the original sum or principal is the compound interest. The number of times a year that interest is converted into principal is called the *frequency*. If interest is compounded quarterly, the frequency is 4; if annually, 1.

Let: P = the principal or original sum.
R = the annual rate of interest.
N = the number of years.
M = the frequency
A = the compounded amount (P + accumulated interest)
I_c = the amount of compound interest accumulated.

Accordingly, if $M = 1$ (that is, interest compounded annually) then, at the end of the first year

$$A_1 = P(1 + R)$$

at the end of the second year

$$A_2 = P(1 + R)\ (1 + R)$$

at the end of the third year

$$A_3 = P(1 + R)(1 + R)(1 + R)$$

at the end of N years

$$A = P(1 + R)^N$$

The term $(1 + R)^N$ is the *compounded amount factor*. Values of this factor for different values of N and R are given in Table XXXVII, page 249.

If M is any other amount, say 4, for example, A is determined by multiplying N by 4 and dividing R by 4. Accordingly, the compounded amount of \$1,000 at 6 percent, compounded quarterly, after 4 years, is

$$A = \$1{,}000\,(1 + 0.015)^{16}$$

The amount of compound interest (I_c) derived from the principal P after N years is the compounded amount A less the principal P. That is,

$$\begin{aligned} I_c &= A - P \\ &= P(1 + R)^N - P \\ &= P[(1 + R)^N - 1] \end{aligned}$$

Figure 55 illustrates some typical cases of compound interest accumulations.

D. THE PRESENT WORTH, AT COMPOUND INTEREST, OF A FUTURE SUM OF MONEY

If a sum of money is to be paid at a distant date as part of a consideration in a transaction, and it is desired to settle all accounts at present so that all parties are cleared of future obligations, the question arises: What is the present worth of the sum to be paid at the distant date? The answer to this question is the same as the answer to the question: What sum put at compound interest (current rates) now will amount to X (the amount to be paid in the future) in N years (the future date)?

The present worth of such a sum is

$$P = \left[A \frac{1}{(1 + R)} \right]$$

The term $\dfrac{1}{(1 + R)^N}$ is known as the *present worth factor*. Values of this factor for different values of N and R are given in Table XXXVIII, page 250.

For example, if \$1,000 is to be paid 3 years from today, and the rate of interest is 6 percent, its present worth is

$$\begin{aligned} P &= \$1{,}000\ [0.8396] \\ &= \$839.60 \end{aligned}$$

In other words, if \$839.60 is put at 6 percent interest, compounded annually, the compounded amount in 3 years would be \$1,000.

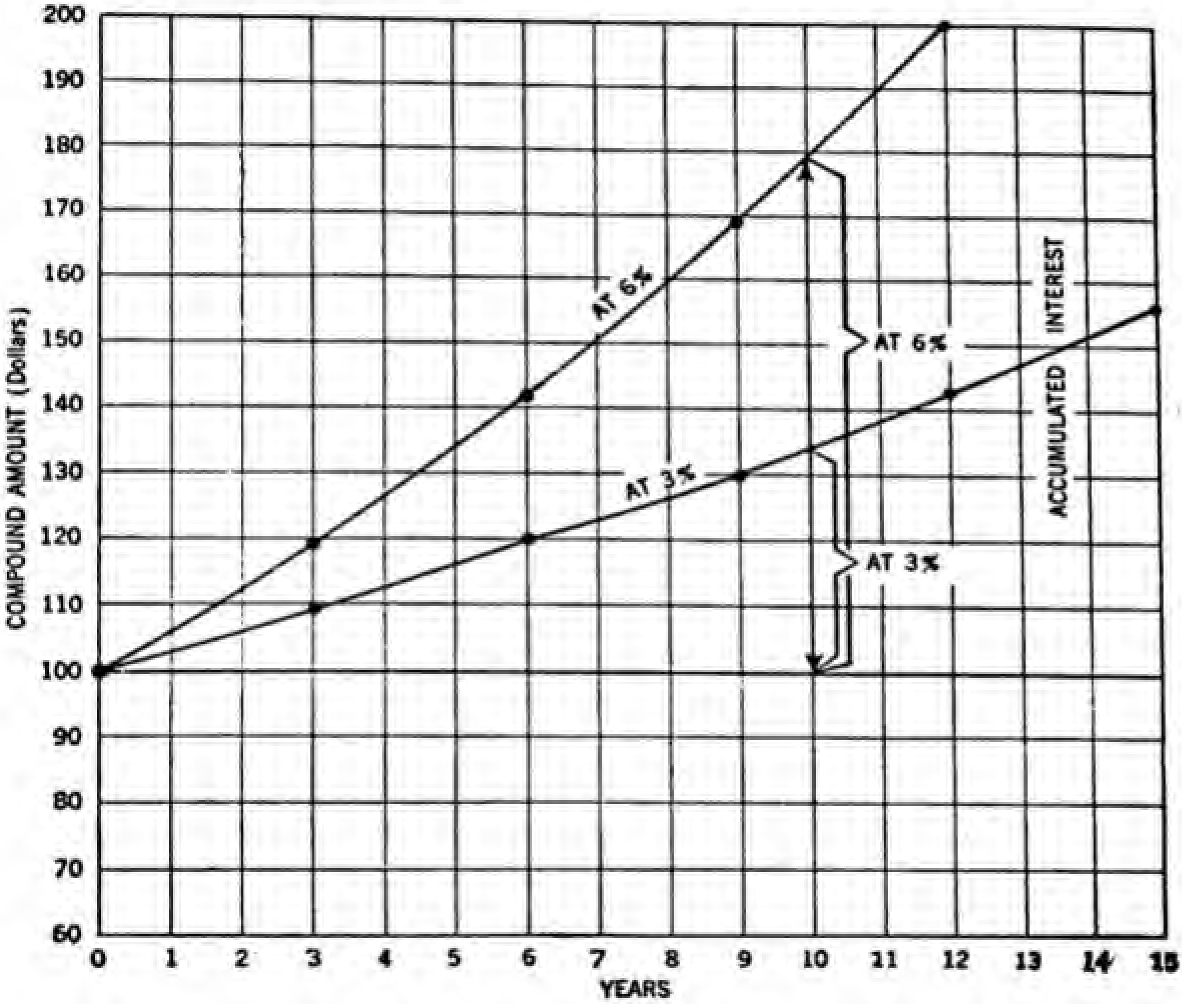

Figure 55. A Graph of Compound Interest Accumulation

The present worth of an anticipated future sum is not only conditioned by the number of years (N) to elapse before realization but also on the rate of interest chosen in estimating the present worth. The rate of interest chosen is determined by the nature of the risk in the contract for realization or future delivery of the anticipated sum.

If, for example, a young man 16 years of age should be heir to a legacy in the form of securities valued at current market prices at \$100,000, and he wishes to sell this legacy, the following questions arise:

a. In the event of his death before the age of 21 years, is the legacy cancelled?

b. What will the legacy probably amount to if earnings on the securities are accumulated up to time of delivery?

c. What are the chances that the securities may decline in value in the next five years, or become worthless due to the failure of the business underlying the securities?

In consideration of any of these or other possibilities, the prospective purchaser will weigh all the chances and decide what rate of interest will in his opinion justify the purchase. Assuming, for example, that the legacy at maturity is estimated by the prospective purchaser to have a probable worth of \$100,000 *based on certain assumptions,* he may believe that the risk is fairly good and determine the present worth on the basis of 6 percent. In this event, he will offer to purchase at

$$\begin{aligned} P &= \$100{,}000 \cdot (.7473) \\ &= \$74{,}730 \end{aligned}$$

If, however, he believes the risk is not so good, he may estimate the present worth on the basis of 8 percent and accordingly offer to purchase at

$$\begin{aligned} P &= \$100{,}000 \cdot (.6806) \\ &= \$68{,}060 \end{aligned}$$

This example and also for the case of a 10-year future expectancy are illustrated in Figure 56.

E. SINKING-FUND DEPOSITS

It is frequently provided in financial arrangements that the borrower must deposit annually a certain sum of money, such that the total of the equal annual deposits at compound interest will amount to the sum to be repaid at the due date.

Let D = the sum of money to be deposited annually * in the sinking fund and compounded annually.

A_F = the amount of money to be repaid or the amount of money to be in the sinking fund at the due date.

N = the number of years during which the sinking fund is to be accumulated. (The number of times the sum of money D is put in the fund.)

R = the rate of interest (annual).

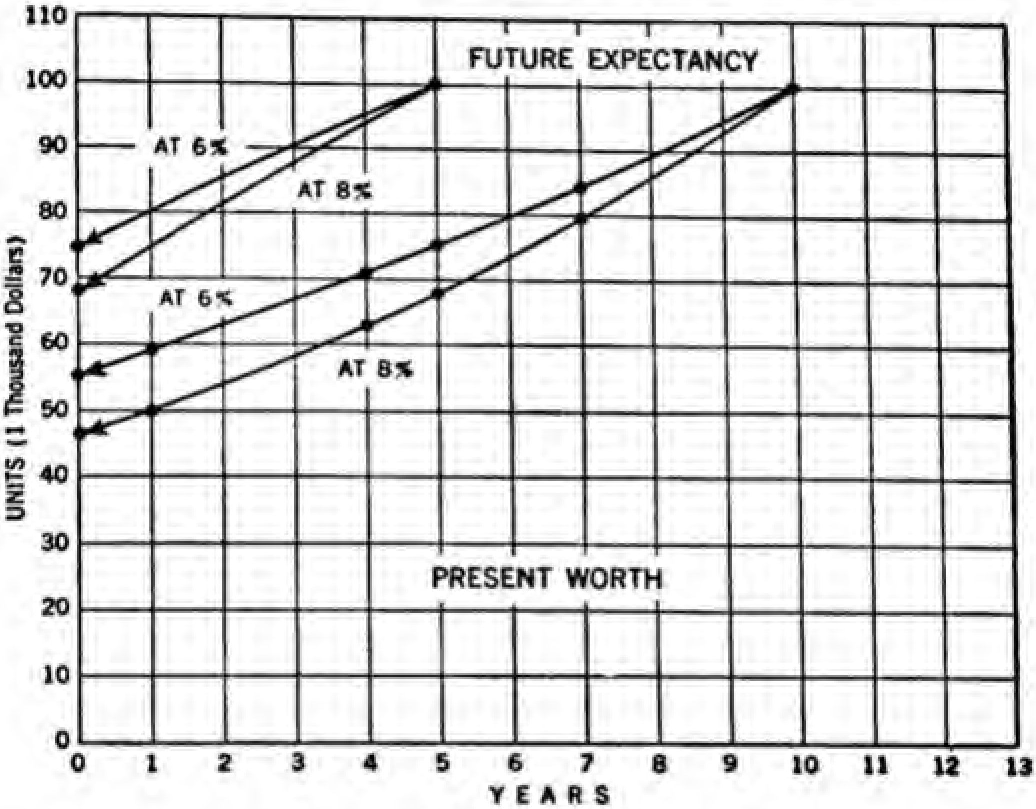

Figure 56. A Graph of Present Worth

Accordingly,

$$A_F = D\,(1 + R)^{N-1} + D\,(1 + R)^{N-2} \ldots + D$$

from which is derived

$$D = A_F \frac{R}{(1 + R)^N - 1}$$

The term $\frac{R}{(1 + R)^N - 1}$ is known as *the sinking-fund factor*. Values

* The first deposit of the series is put in the fund at the end of the first year. It will be compounded annually for (N − 1) years. The last deposit is put in at the due date.

of the sinking-fund factor for different values of N and R are given in Table XXXIX, page 251.

Example. What annual sinking-fund deposits at 6 percent compound interest are required to provide a fund to redeem a debt of $10,000 maturing ten years from date?

Solution. D = 10,000 (0.07587) = $758.70

The graph of the above problem and its solution is given in Figure 57. For purposes of comparison, there is also shown in Figure 57 the

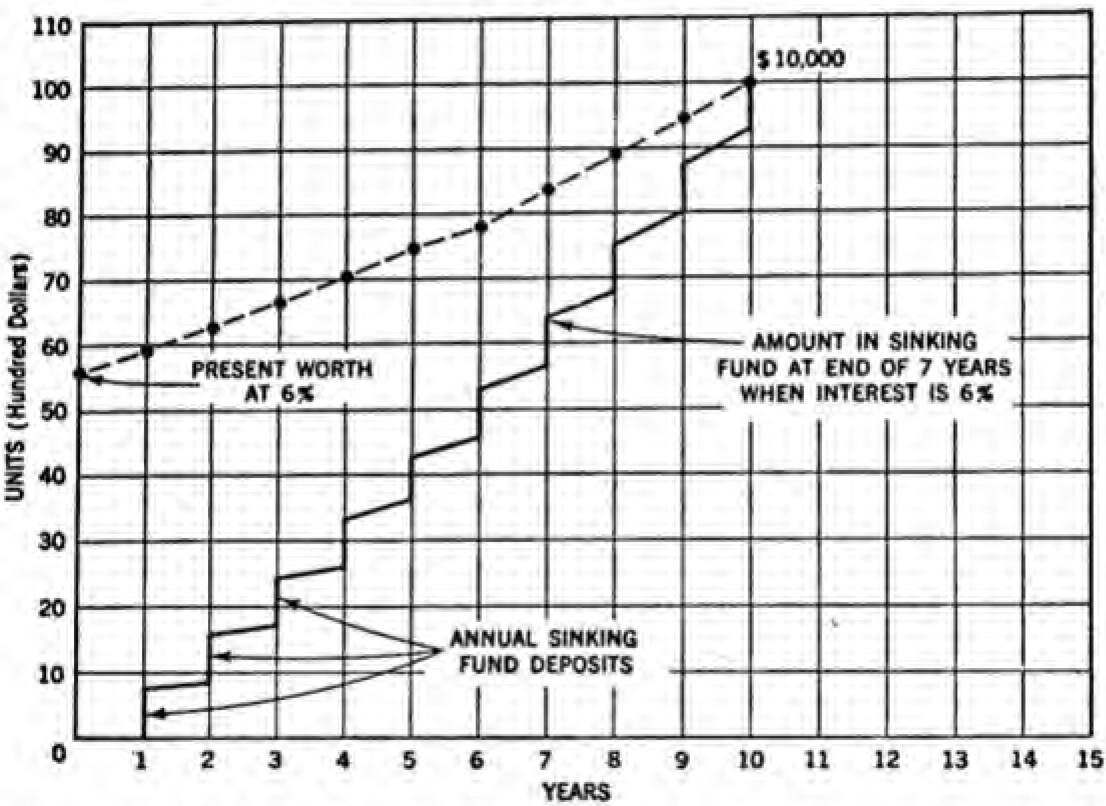

Figure 57. A Graph of Sinking Fund Accumulations with Present Worth of Final Fund

present worth of $10,000 at 10 years hence on the basis of 6 percent annually compounded interest. This present worth ($5,584) is that sum of money which, if deposited at 6 percent annual compound interest, would amount to $10,000 after 10 years. These comparisons (present worth and annual deposits) are important for the visualization of some aspects of investment which are about to be described.

F. CAPITAL RECOVERY

a. Deposits may be required to be made annually in a sinking fund to redeem a loan which bears interest compounded annually. A lender may be willing to risk a loan of, say, \$100,000, to be repaid with compound interest at the end of 10 years, but because of some speculative features of the undertaking, for which the money is to be used, the lender demands interest on his money at the rate of 10 percent compounded annually. He, furthermore, as additional protection, requires the borrower to deposit annually in a trust fund in a savings bank, that sum of money which at 4 percent compound interest will in 10 years equal the \$100,000 plus interest *at 10 percent* compounded annually. Under these circumstances the amount of money to be accumulated in the trust fund (sinking fund) is the compounded amount of \$100,000 for 10 years *at 10 percent*. That is

$$A_P \text{ must equal } P\ (1 + R)^N$$

Therefore:

$$D \text{ must equal } P\ (1 + R)^N \frac{R'}{(1 + R')^N - 1}$$

in which
$P = \$100{,}000$
$R = 10$ percent
$R' = 4$ percent
$N = 10$ years

Since $(1 + R)^N =$ the compounded amount factor

and $\dfrac{R'}{(1 + R')^N - 1} =$ the sinking-fund factor it appears that

capital recovery in N years at interest R compounded annually to be redeemed through equal annual deposits in a sinking fund which is compounded annually at R′ percent, is

$$D = P\ (\text{compounded amount factor}) \cdot (\text{sinking fund factor})$$

evaluated in terms of the interest rates applying to each factor. Thus, in the example cited above:

$$D = \$100{,}000\ (2.594) \cdot (0.08329) = \$21{,}605.43$$

b. In case the interest rate applying to the sinking fund is equal to the interest rate applying to the loan, and that interest rate is R,

Then,

$$D = P\,(1+R)^n\left[\frac{R}{(1+R)^n-1}\right]$$

$$= P\left[R+\frac{R}{(1+R)^n-1}\right]$$

$$= P\ (\text{capital recovery factor})$$

The capital recovery factor = R + sinking-fund factor. The reciprocal of the capital recovery factor is known as the Inwood Factor. Accordingly,

$$D \cdot (\text{Inwood Factor}) = P$$

c. There are situations in which the investor demands equal annual cash payments (PR), for use in meeting living expenses, plus equal annual deposits (D) in a sinking fund compounded annually at the interest rate (R′) to provide for capital recovery after a specified number of years. The borrower under the circumstances must meet an annual obligation of

$$PR + P\left[\frac{R'}{(1+R')^n-1}\right]$$

or

$$P\left[R+\frac{R'}{(1+R')^n-1}\right]$$

or $\qquad P \cdot (\text{simple interest} + \text{sinking fund factor})$

If, therefore, \$100,000 is borrowed for 10 years with the provision that the lender is to be paid \$6,000 annually and a sinking-fund is to be set up bearing 4 percent compound interest, which fund will amount to \$100,000 in 10 years, the equal annual deposits in the fund will be

$$D = \$100{,}000\ (0.08329)$$
$$= \$8{,}329$$

The annual obligation the borrower must meet will be

$$\$6{,}000 + \$8{,}329 = \$14{,}329$$

d. If the borrower should demand not only equal annual cash payments (PR) but also that his capital (P) be returned in 10 years at compound interest (R″) to be provided through a sinking fund, the

annual deposits in which shall be compounded annually at the interest rate (R′), then such annual deposits are

$$D = P\,(1 + R'')^{x}\left[\frac{R'}{(1+R')^{x}-1}\right]$$

and the annual obligations to be met by the borrower become

$$PR + P\,(1 + R'')^{x}\left[\frac{R'}{(1+R')^{x}-1}\right]$$

G. EOUIVALENCE

Money may be borrowed upon different terms of repayment of the loan with interest. The usual methods are:

A. To pay the entire loan at the end of the period, but pay the amount of interest annually or semiannually as specified.
B. Reduce the principal by equal amounts each year and pay the amount of interest on the remaining balance.
C. Pay equal amounts each year such that the total annual payments will equal the principal plus interest on remaining balances for the entire period of the loan. Part of the equal amounts paid each year will be credited to the reduction of the loan after the appropriate interest on the remaining balance has been deducted.
D. Pay the entire loan, with annual compound interest, at the end of the period.

These four methods are equivalent in respect of the rate of interest paid on the actual sum of money in possession of the borrower at all times. They each pay the same rate of interest. The results of operating under each of these four plans of repayment of a loan of $10,000 at 6 percent for a period of 10 years are shown in the following table. But they are not equivalent in respect of the sum of the present worth of all the year-end payments if the present worth is calculated at an interest rate differing from that of the loan. For example, the sum of the year-end payments in each case is the present worth of the total of future payments, when the interest rate is zero. Thus, under Plan A the present worths of the total of year-end payments at 0 interest is $16,000; Plan B $13,300; Plan C $13,587; and Plan D $17,908. If the interest rate should be 6 percent, for example, the sum of the present worths of the year-end payments would each be $10,000. If the interest rate should be 4 percent, they would be: Plan A $11,620; Plan B $10,940; Plan C $11,020; and Plan D $12,100 (see Table XXXVI).

TABLE XXXVI

FOUR PLANS FOR THE REPAYMENT OF A LOAN OF $10,000, AT 6 PERCENT FOR 10 YEARS

Plan	End of Year	Year-end Payments	Remaining Balances
	1	$ 600	$10,000
	2	600	10,000
	3	600	10,000
	4	600	10,000
A	5	600	10,000
	6	600	10,000
	7	600	10,000
	8	600	10,000
	9	600	10,000
	10	10,600	0
	1	$ 1,600	$ 9,000
	2	1,540	8,000
	3	1,480	7,000
	4	1,420	6,000
B	5	1,360	5,000
	6	1,300	4,000
	7	1,240	3,000
	8	1,180	2,000
	9	1,120	1,000
	10	1,060	0
	1	$ 1,358.68	$ 9,241.32
	2	1,358.68	8,437.12
	3	1,358.68	7,584.67
	4	1,358.68	6,681.07
C	5	1,358.68	5,723.25
	6	1,358.68	4,707.98
	7	1,358.68	3,631.77
	8	1,358.68	2,491.00
	9	1,358.68	1,281.78
	10	1,358.68	0.00
	1.	$ 0	$10,600.00
	2	0	11,236.00
	3	0	11,910.16
	4	0	12,624.77
D	5	0	13,382.26
	6	0	14,185.20
	7	0	15,036.31
	8	0	15,938.49
	9	0	16,894.80
	10	17,908.49	0.00

Accordingly, if a loan is made at an interest R and any one of the four plans of repayment is adopted, the present worths at any other interest rate will not be equivalent.

The importance of this observation lies in the fact that the real interest rate paid on a loan depends on the plan of repayment and may be quite different from the declared interest rate. For example, if a bank loans a customer $1,000 for a period of 10 months at a declared interest rate of 6 percent, discounts the note at the beginning of the period, and requires the borrower to repay the loan in 10 equal payments of $100 each at the end of each month, we find that the following takes place. The bank takes $60 of the $1,000 and therefore gives the borrower only $940. At the end of the first month the borrower pays $100 and then has the use of only $840 during the second month. During the third month he has the use of only $740, and during the last month only $40. The average of the monthly sums in his possession is $490, for which he pays $60 *in advance*. If he should really pay interest at the rate of 6 per cent per year, which is one-half percent per month, at the end of each month *after the service had been rendered,* his interest costs would be at the average of $2.45 per month or $24.50 for the entire period of the loan. Thus the bank is really charging him more than twice as much as the declared interest rate. The determination of the exact interest paid in this case requires a rather involved computation and will not be given. The important matter to be observed is that the interest really paid may not always be that which is declared.

H. WHEN TO INCLUDE INTEREST

It is a widely accepted practice in estimating certain costs to include the interest on the investment as an item of cost whether or no any moneys are borrowed for the purpose of making the investment. That is, if one should pay $7,000 cash for a machine or purchase it on open account, in estimating the cost of production by the use of this tool, an interest charge of, say, 6 percent on the $7,000 is considered a proper charge as part of the annual cost to possess the machine. The writers feel that this practice is likely to lead to errors in judgment. It would appear that a fundamental purpose in cost accounting is to account for all the items of cost which are incurred. If, therefore, one borrows $7,000 to buy a machine and pays 6 percent on the money, naturally one of the costs of possessing the machine is $420 annually. If, however, one has $7,000 to invest, he may do one

of two things. He may lend it to someone through the purchase of a bond, for example, and receive 6 percent interest on his investment, or he may invest it in a piece of equipment he intends to use in production. In making his decisions he will estimate the probable returns on his investment in the equipment and its use in production as compared to the return he would get if he lent the money to another. If his estimates show that by purchasing the equipment and using it in production there is a probability of a return of 12 percent on his investment, he can then say that by investing in the machine there is a probability that he will receive 6 percent *more* on his investment than by lending it to another.

He must then determine the margin of hazard between the two situations and make his decision on the basis of whether or not the margin of hazard covers the probability of a 6 percent additional return.

If he does not have $7,000 and can borrow the money and then make the investment in the equipment for use in production he will have a probability of a return of 6 percent.

The writers feel that it should be fundamental in accounting practice, as stated above, to account only for actual situations as they exist and not for what they might be under other circumstances. Suppose that we carry the illustration still further. If a $7,000 machine is purchased for cash, no money is borrowed, and the machine is estimated to have a life of 7 years, then the products manufactured by the machine will be charged $1,000 per year for a period of 7 years, and in this way the investor sells his machine to his customers and recovers his original investment at the end of 7 years. Assume then that he goes out of business. He has his original investment of $7,000 and, in addition, has made a profit of 12 percent a year during the 7 years in which he has used his capital in this manner. Now, suppose that he added an item of 6 percent on the investment to the production cost and had charged his customers an additional $420 per year. At the end of 7 years, he would not only have recovered his original investment through the depreciation charge but also would have received, in addition, 7 · $420 or $2,940. He, therefore, would have made not only the 12 percent through the use of the machine in manufacturing but also an additional 6 percent, or a total of 18 percent in all. If he did not borrow the money from anyone, there is, therefore, no one to whom he has to pay 6 percent, and it is his own. Or suppose that he had estimated his costs to include interest and on this basis his books showed a profit of 6 percent on his investment. When he balances his

cash he finds he has made a gain of 12 percent, or twice as much as he estimated. Many accountants do not agree with this point of view, but the writers feel nevertheless that it is a correct one.

I. APPLICATIONS

a. *Investing in a New Machine*

When a businessman considers an investment he examines the matter with reference to:

(1) The safety of capital, and
(2) The probable return or earnings.

He makes the investment with the prospect of getting his money back at some future date plus interest. If he buys stocks or bonds for investment he deals with an investment banker or a broker who acquaints him with the data relating to the enterprise underlying the securities, from which he forms his judgment. The manufacturer is also an investor and when he considers buying a new and improved type of machine he also wants to know how safe is his capital and what the probable returns or earnings may be. He also wants eventually to get his money back with satisfactory interest. His process of reasoning in making such purchases is about as follows. Let us assume that by the use of his present processes a given set of operations in his factory costs, say, \$10,000 per year at current rates of production. He is offered a machine or group of machines which, estimates show, will lower the cost of production, including depreciation in 5 years, at the current rate of output by \$2,000 per year. The machinery is offered at the price of \$20,000. Is it a good buy *at the price offered*?

The first question to be answered is: How soon should the capital be recovered with interest? Business conditions and the state of the arts, both with reference to the products made and the probability of even better machinery being available within the next few years, often prompt the manufacturer to want to recover his investment with interest, say, in five years, even though the estimated *mechanical* usefulness of the machine may be 10 or more years. Let us assume then that the *economic* usefulness of the machine is accepted as 5 years. As an investment, then, the problem begins to take the form of the sinking fund problem presented above. Let us assume that the annual savings of \$2,000 are considered as sinking-fund deposits and that they are put at interest at current rates, say 4 percent, compounded annually.

It appears, therefore, that the accumulated amount in the fund at the end of 5 years will be

$$A_F = (\$2,000 \div 0.18463) = \$10,832$$

The compounded amount of \$20,000 (the investment in the machine), in 5 years at 8 percent interest (assuming that 8 percent is indicative of the risk), is $\$20,000 \cdot 1.469 = \$29,380$, from which it is found that the accumulated interest on the investment is \$9,380. Since one fifth of the investment in the machine is recovered each year through depreciation, the accumulated interest on the average annual investment is much less. For example:

The \$20,000 invested in the machine is returned through adding \$4,000 each year to the cost of the products made by the machine. Thus, at the end of the first year, only \$16,000 remains as unrecovered investment, at the end of the second year only \$12,000 remains as unrecovered investment, etc., etc. Accordingly, during the five-year life of the machine the average investment is \$20,000 for one year; \$16,000 for one year; \$12,000 for one year; \$8,000 for one year and \$4,000 for one year, or an average of \$12,000 for 5 years. If 8 percent interest is indicative of the risk, then the return on the average annual investment should be $.08 \cdot \$12,000 = \$960.00$ per year or $5 \cdot 960 = \$4,800$ for 5 years.

Since the annual savings from the use of the new machinery will, in 5 years at 4 percent compound interest, amount to \$10,832, it appears that the investment of \$20,000 in the new machinery will yield a return greater than 8 percent, and therefore the investment is justified since it more than meets the risk demand prescribed.

But how about the return of the capital invested? It will be noted above that the estimated savings of \$2,000 per year were based on cost calculations which included depreciation as an item of cost. This means that the annual depreciation (which, if estimated on a straight time basis, is \$4,000 per year) is charged into costs and as such is recovered in sales to the customers of the products of the machine. In a period of 5 years the \$4,000 annual depreciation deposited in the depreciation reserve fund (but not at interest) will amount to \$20,000. Accordingly, on the basis of the estimates of the costs of production in which the use of a new machine costing \$20,000 will result in annual savings of \$2,000 over present processes *after accounting for full depreciation* in 5 years, the investment may be considered satisfactory both as to the return of the original capital invested and also as to the interest on the investment.

b. *Investing in an Apartment House*

Should an investor be offered an apartment house at a specified price, how should he determine whether or not the purchase price represents a good investment? His approach to this problem should be as follows. First, he should determine the probable annual income from rentals, not only at present but for the future, say the next 25 years. At the same time he must determine the probability of real estate values in the neighborhood being maintained or even enhanced. Volumes may be written on both these problems (future income and future value) but we will not be concerned with these matters at this time. Second, he should determine the probable expenses for maintenance, repairs, upkeep, and other operating items and the annual depreciation. The difference between income and expense constitutes the probable annual net income for say 25 years.

If these annual net incomes (D) are deposited in a fund which is compounded at R percent for N years, then the amount accumulated in the fund after N years will be

$$A_F = D \cdot \left(\frac{1}{\text{sinking fund factor}}\right)$$

The present worth of this fund at an interest rate of R′ compounded annually will be

$$P = A_F \cdot (\text{present worth factor})$$

P then is the price at which the apartment house may be purchased as an investment to return an interest of R′ compounded annually for 25 years. The above relationships are illustrated in Figure 55.

To illustrate more fully the complete procedure in appraising the value of such properties for investment purposes, we reproduce below an article on this subject by Mr. Victor J. Free in the *Journal of the American Institute of Real Estate Appraisers*, January, 1938.

Great Lakes City, Ohio
December 11, 1937

Prairie Central Life Insurance Company
Osborne City, Iowa
Gentlemen:

Pursuant to your request of December 4, 1937, I have examined with care the property at 1115 South Jones Street in the city of Great Lakes, Ohio, and return herewith as of December 11, 1937, this estimate of market value: *Twenty-four thousand, five hundred dollars* ($24,500).

The purpose of this appraisal is that you may determine whether the renewal of a mortgage upon this ten-suite apartment property is advisable and for the best interest of your company. Therefore, I have considered market value only, leaving to your judgment the loan percentage of such value which you may consider safe and equitable.

I determined the market value to be the present worth of all the future benefits arising from ownership of this property—the present worth of a stream of net earnings during the reasonable remaining life of the building—to which I added the reversionary land value at the time the building has been exhausted.

In reaching this estimate of value I have relied upon the following:

(1) Neighborhood analysis and remaining expectant life.
(2) Rental levels of the neighborhood and their probable continuance.
(3) Economic and social forces in the city and neighborhood.
(4) A fair annual level of net income.
(5) The property residual procedure and the compound interest valuation premise, using the Inwood tables.
(6) An over-all capitalization rate with adjustment for land and building values, determined by comparison.

I thank you for this opportunity for serving you and trust that the report will be found satisfactory.

Yours very truly,
Richard Roe, M.A.I.
Appraiser

THE APPRAISAL

LEGAL DESCRIPTION:

Situated in the city of Great Lakes, Ohio, and known as sublot No. 120 in the Jones and Marshall Subdivision of Tract 4, Range 14, as shown in Volume 8, P. 112, of the records of Great Lakes County. Said sublot No. 120 is located on the northerly side of South Jones Street and has a frontage of 60 feet thereon, extending back between parallel lines to a depth of 136 feet, be the same more or less but subject to all legal highways.

GREAT LAKES CITY:

Great Lakes City is the western metropolis of Ohio, a railroad center and the trading point for a vast, productive, and wealthy agricultural community. It is a merchandising mart and an industrial, manufacturing, and distributing center for a population of one million people. Its schools, churches, chamber of commerce, and public agencies are characteristic of its youth, its civic vision, and its social and economic stability. During the late depression it suffered less than most metropolitan areas, and its recovery has been rapid. It has a good local government and high civic ideals, and is altogether a prosperous and forward-looking community. Its industries, railroads, and merchandising and financial agencies indicate a continuance of more than a normal increase in population and wealth.

THE NEIGHBORHOOD:

South Jones Street is located four and one-half miles northwest of the center of the city. It is reached by surface street cars at its intersection with West Market Street, two blocks from the subject property, and the running time to the central business district is twenty minutes. Intersecting surface lines at transfer points bring all parts of the city into easy communication. City-owned and city-operated bus lines, connecting with car lines and reaching newly developed areas, furnish additional transportation for this neighborhood.

This area was developed twenty-two years ago. It has all public utilities, paved streets, and easy access to boulevards that reach the business districts with a minimum of traffic hazards. The entire area is substantially level.

ZONING AND RESTRICTIONS:

The neighborhood is restricted to residential use with the exception of the four corners at the intersection of Jones and Market Streets, where retail business and automobile service stations are located. These restrictions, in conformity with later zoning, have produced single, two-family, and apartment houses. South Jones Street in this neighborhood has nine single houses, eighteen two-family houses, eleven apartment buildings, and four vacant lots. It is typical of the several streets north and south of Market Street which comprise the neighborhood.

This is not a new neighborhood, and it is not a stylish one. As a whole, the section has suffered from age and undesirable racial encroachment. It is a secondary apartment neighborhood in which buildings have an average age of eighteen years. It is attractive to middle-class families, whose incomes range from $1,500 to $3,000 per year and whose rental outlay lies between $30 and $60 per month. Sixty percent of single and two-family houses are owner-occupied. Statistics show an over-all residential vacancy ratio of 8 percent for 1935, 6.5 percent for 1936, and 5 percent as of September 1, 1937. In 1935 and 1936, a total of seventy-one families moved into it. This movement in a population of approximately 900 families indicates a stable and desirable rental situation for the neighborhood.

LAND:

The values of this land, established by comparison with sales, offers to purchase, and brokers' listings, is estimated to be $4,000. It now serves its highest and best use.

BUILDING:

The building was erected in 1924 and contains ten rentable suites—eight with five rooms and one bath each, and two with three rooms and one bath each. It is a two-story and English basement building, with wire-cut tapestry brick with stone trim on all elevations. The two rentable suites of three rooms and bath are located in the basement, and there are four of the five-room suites on each of the first and second floors; in addition, there is a three-room basement suite for the janitor.

CONSTRUCTION:

The basement has concrete floors and a ceiling height of nine feet. The three suites located in the front of the basement are separated by a twelve-inch brick fire wall from the rear basement, which contains the boiler room, the laundry, and the lockers. The ceiling of the rear basement is plastered, and the walls are painted hollow tile. An examination of the plans in the building commissioner's office showed footings three feet below floor level and three-inch by twelve-inch yellow pine floor joists on twelve-inch centers, braced and bridged in conformity with good building practice. There is no evidence of termites or dry rot. Basement walls are eighteen inches thick, while the walls above grade are thirteen inches thick and have a four-inch brick course over eight-inch hollow tile.

The roof is of six-ply composition built-up construction and slopes to roof drains at the rear of the building.

All outside openings are fully weather-stripped. There is one principal entrance to the building from South Jones Street. The fire escape and service stairways are at the rear. The lobby has plastered and painted walls with tile floor and oak stairways leading to the basement and upper floors. Center halls, extending lengthwise on the first and second floors, divide the space so that there are two suites on each side of each hall.

INTERIOR OF SUITES:

All floors are seven-eighths-inch oak over diagonally laid subfloors. The doors and trim are birch, and the kitchen floors are covered with linoleum. The bathrooms have tile floors, built-in tubs with overhead showers, three-quarters tiled walls, and a fair grade of fixtures, with pedestal washstands and semi-noiseless, low flush toilets.

Each five-room suite has two bedrooms, each with a clothes closet; living room with guest closet, bookshelves, gas log fireplace, and birch mantle; dining room with corner china cabinets; and kitchen equipped with cupboards, shelves, roll-rim sink, broom closet, ironing board, and refrigerator space. The light is fair in all rooms, but it does not meet modern requirements in better-planned buildings. The three-room suites have the same type of floors and trim as the larger suites. They have one bedroom each and an in-a-door bed in the living room. Bathroom fixtures are identical with those of the larger suites.

Each kitchen of the ten rentable suites is equipped with a gas stove and an electric refrigerator. All window shades, curtain rods, and gas logs also belong to the property.

EQUIPMENT:

A sixty-horsepower steam boiler from the Titusville Iron works (Titusville, Pa.) was installed when the building was erected and has been efficiently maintained. Its record of performance is good. There is a submerged hot-water heating installation with a 300-gallon tank and an instantaneous gas-heated hot-water unit for use in summer months. The heating system is a two-pipe return system with low-type radiators. All

heating pipes are covered. Radiation seems adequate, and the tenants appear satisfied.

Cast-iron water piping has been used in all cases except for elbows, fittings, and valves of the hot-water lines which are of copper. There is no evidence of serious rust or corrosion. All electric wires are in conduits; outlets are sufficient in number. However, electric fixtures are out of date and should be replaced. All gutters and downspouts are copper. Call tubes and mailboxes for all suites are located in the vestibule.

CONDITION:

The general condition of the building is good, with the following exceptions: All exterior woodwork and the iron stairways in the rear should be painted. Old electric fixtures in the living rooms, dining rooms, and the entrance vestibule should be replaced. The same applies to the hall carpeting on the first and second floors. These improvements will cost approximately $600 and are considered necessary for continued desirability of the suites.

TAX VALUATION:

This property is valued for taxation as follows:

Land	$ 3,600.00
Building	12,600.00
Total	$16,200.00

The tax rate is $25.60 per $1,000 valuation, making the present annual taxes $414.72.

REPRODUCTION COST (NEW):

Building 42′ · 90′ · 30′ = 113,400 cu. ft.		
113,400 cu. ft. @ $0.35 = estimated cost new		$39,600.00
Depreciation		
Physical	$ 6,500.00	
Equipment (restoration)	600.00	
Obsolescence (changing neighborhood) *	10,000.00	17,100.00
Indicated value of building		22,500.00
Value of land (comparison)		4,000.00
Indicated property value		$26,500.00

* In a consideration of the loss through the changing neighborhood, it was estimated that this building after expenditure of $600 for renewal of equipment, if located in a 100 percent neighborhood, would bring rentals above present levels of $10 per month for the five-room suites and $5.00 per month for the three-room suites. If this added annual rental of $1,080, less 10 percent for vacancies and 5 percent for management charge, is treated as added income for the remaining life of the building and the present worth of such estimated additional income is computed, we have 10.594 (Inwood factor for 20 years at 7%) · $918, or $9,725. This is considered for purposes of this appraisal to be $10,000.

ECONOMIC PROCEDURE:

Gross Income		
4 suites @ $50 per month = $200		$2,400.00
4 suites @ $45 per month = 180		2,160.00
2 suites @ $35 per month = 70		840.00
Total gross income		$5,400.00
Less: Vacancy and rental loss (10%)		540.00
Gross effective rental		$4,860.00
Operating Costs	Per Year	
Coal (98 tons @ $5)	$490.00	
Decorating, paint, and shades	400.00	
Exterior maintenance	100.00	
Water (actual)	110.00	
Electricity (actual)	220.00	
Gas (actual)	50.00	
Janitor (plus suite)	240.00	
Miscellaneous	70.00	
Management	245.00	
		1,925.00
Fixed Charges		
Taxes (actual)	414.72	
Insurance (actual)	172.00	
		586.72
Reserve for Replacements		
Refrigerators (15-year life)	84.00	
Stoves (15-year life)	20.00	
Carpet (8-year life)	27.00	
Roof (15-year life)	24.00	
Boiler (15-year life)	50.00	205.00
Total charges		$2,716.72
Net income to property		2,143.28
Say		$2,150.00

ASSUMPTIONS:

1. That rental levels may be stabilized upon the preceding basis for twenty years.

2. That the property residual pattern best fits this property.

3. That a 7 percent interest rate for the investor and a 4 percent basis for land reversion are fair and equitable.

4. That the Inwood procedure of the compound interest valuation premise is indicated.

PROCEDURE:

10.594 Inwood factor 20 year 7% · \$2,150	\$22,777.10
0.4564 Factor for 20 year reversion 4% · \$4,000	1,825.60
Indicated value of property	\$24,602.70
Say	\$24,600.00

Comparative Results:

Reproduction cost, less depreciation	\$26,500.00
Capitalization of estimated net income	24,600.00
Estimate of market value	24,500.00

CERTIFICATION:

I hereby certify that I have examined this property personally; that I have checked and considered rentals paid in a wide neighborhood; that I have compared this building and these rental units with other similar property; and that I have considered maintenance, management, and competitive prices. As a result of the foregoing and other things, I have placed my reliance in the economic approach, using physical reproduction only as a check thereon. In my opinion the property herein appraised has a market value as of this date, December 11, 1937, of *twenty-four thousand, five hundred dollars* (\$24,500).

Richard Roe, M.A.I.
Appraiser

c. *Investing in a Mine*

In the case of an ore body, the mining engineer can estimate with a high degree of probability the quantity of ore underlying the property and also determine the investment in plant to mine and smelt the ore. Assume that a given ore deposit is found to be 600,000 tons and that an economical plant can be installed to mine and smelt the ore at the rate of 60,000 tons per year. Assume also that it is estimated that the net annual income from operations will be \$200,000. This income is based on a cost which includes a full write-off or depreciation of the plant investment in 10 years. What price should one pay for this property to meet the following investment requirements:

1. That the original price paid be returned in 10 years with interest at 10 percent compounded annually; and
2. That the annual net income from operations be invested in securities bearing 3 percent interest.

In the matter of requirement (2), we find

$$A_F = \$200{,}000 \cdot \left(\frac{1}{\text{sinking-fund factor}}\right)$$
$$= \frac{\$200{,}000}{0.08723}$$
$$= \$2{,}300{,}000 \text{ (approximately)}$$

The present worth of this expectancy on the basis of 10 percent interest is,

$$P = \$2{,}300{,}000 \text{ (present worth factor for 10 years at 10 percent)}$$
$$= \$2{,}300{,}000\ (0.3855)$$
$$= \$886{,}650 \text{ (approximately)}$$

This, then, is the price to be paid for the property plus the mining and smelting plant to meet the investment demands above specified.

TABLE XXXVII

VALUES OF THE COMPOUNDED AMOUNT FACTOR $(1 + R)^N$

N	3%	4%	5%	6%	7%	8%	10%
1	1.030	1.040	1.050	1.060	1.070	1.080	1.100
2	1.061	1.082	1.103	1.124	1.145	1.166	1.210
3	1.093	1.125	1.158	1.191	1.225	1.260	1.331
4	1.126	1.170	1.216	1.262	1.311	1.360	1.464
5	1.159	1.217	1.276	1.338	1.403	1.469	1.611
6	1.194	1.265	1.340	1.419	1.501	1.587	1.772
7	1.230	1.316	1.407	1.504	1.606	1.714	1.949
8	1.267	1.369	1.477	1.594	1.718	1.851	2.144
9	1.305	1.423	1.551	1.689	1.838	1.999	2.358
10	1.344	1.480	1.629	1.791	1.967	2.159	2.594
11	1.384	1.539	1.710	1.898	2.105	2.332	2.853
12	1.426	1.601	1.796	2.012	2.252	2.518	3.138
13	1.469	1.665	1.886	2.133	2.410	2.720	3.452
14	1.513	1.732	1.980	2.261	2.579	2.937	3.797
15	1.558	1.801	2.079	2.397	2.759	3.172	4.177
16	1.605	1.873	2.183	2.540	2.952	3.426	4.595
17	1.653	1.948	2.292	2.693	3.159	3.700	5.054
18	1.702	2.026	2.407	2.854	3.380	3.996	5.560
19	1.754	2.107	2.527	3.026	3.617	4.316	6.116
20	1.806	2.191	2.653	3.207	3.870	4.661	6.727
21	1.860	2.279	2.786	3.400	4.141	5.034	7.400
22	1.916	2.370	2.925	3.604	4.430	5.437	8.140
23	1.974	2.465	3.072	3.820	4.741	5.871	8.954
24	2.033	2.563	3.225	4.049	5.072	6.341	9.850
25	2.094	2.666	3.386	4.292	5.427	6.848	10.835

TABLE XXXVIII

VALUES OF PRESENT WORTH FACTOR

$$\frac{1}{(1+R)^N}$$

N	3%	4%	5%	6%	7%	8%
1	0.9709	0.9615	0.9524	0.9434	0.9346	0.9259
2	0.9426	0.9246	0.9070	0.8900	0.8734	0.8574
3	0.9151	0.8890	0.8638	0.8396	0.8163	0.7938
4	0.8885	0.8548	0.8227	0.7921	0.7629	0.7350
5	0.8625	0.8219	0.7835	0.7473	0.7130	0.6806
6	0.8375	0.7903	0.7462	0.7050	0.6663	0.6302
7	0.8131	0.7599	0.7107	0.6651	0.6227	0.5835
8	0.7894	0.7307	0.6768	0.6274	0.5820	0.5403
9	0.7664	0.7026	0.6446	0.5919	0.5439	0.5002
10	0.7441	0.6756	0.6139	0.5584	0.5083	0.4632
11	0.7224	0.6496	0.5847	0.5268	0.4751	0.4289
12	0.7014	0.6246	0.5568	0.4970	0.4440	0.3971
13	0.6810	0.6006	0.5303	0.4688	0.4150	0.3677
14	0.6611	0.5775	0.5051	0.4423	0.3878	0.3405
15	0.6419	0.5553	0.4810	0.4173	0.3624	0.3152
16	0.6232	0.5339	0.4581	0.3936	0.3387	0.2919
17	0.6050	0.5134	0.4363	0.3714	0.3166	0.2703
18	0.5874	0.4936	0.4155	0.3503	0.2959	0.2502
19	0.5703	0.4746	0.3957	0.3305	0.2765	0.2317
20	0.5537	0.4564	0.3769	0.3118	0.2584	0.2145
21	0.5375	0.4388	0.3589	0.2942	0.2415	0.1987
22	0.5219	0.4220	0.3418	0.2775	0.2257	0.1839
23	0.5067	0.4057	0.3256	0.2618	0.2109	0.1703
24	0.4919	0.3901	0.3101	0.2470	0.1971	0.1577
25	0.4776	0.3751	0.2953	0.2330	0.1842	0.1460

TABLE XXXIX

VALUES OF SINKING FUND FACTORS

$$\frac{R}{(1+R)^{N}-1}$$

N	3%	4%	5%	6%	7%
1	1.00000	1.00000	1.00000	1.00000	1.00000
2	0.49261	0.49020	0.48780	0.48544	0.48309
3	0.32353	0.32035	0.31721	0.31411	0.31106
4	0.23903	0.23549	0.23201	0.22859	0.22523
5	0.18835	0.18463	0.18097	0.17740	0.17389
6	0.15460	0.15076	0.14702	0.14336	0.13980
7	0.13051	0.12661	0.12282	0.11914	0.11555
8	0.11246	0.10853	0.10472	0.10104	0.09747
9	0.99843	0.09449	0.01069	0.08702	0.08349
10	0.08723	0.08329	0.07950	0.07587	0.07238
11	0.07808	0.07415	0.07039	0.06679	0.06336
12	0.07046	0.06655	0.06283	0.05928	0.05590
13	0.06403	0.06014	0.05646	0.05296	0.04965
14	0.05853	0.05467	0.05102	0.04758	0.04434
15	0.05377	0.04944	0.04634	0.04296	0.03979
16	0.04961	0.04582	0.04227	0.03895	0.03586
17	0.04595	0.04220	0.03870	0.03544	0.03243
18	0.04271	0.03899	0.35555	0.03236	0.02941
19	0.03981	0.03614	0.03275	0.02962	0.02675
20	0.03722	0.03358	0.03024	0.02718	0.02439
21	0.03487	0.03128	0.02800	0.02500	0.02229
22	0.03275	0.02920	0.02597	0.02305	0.02041
23	0.03081	0.02731	0.02414	0.02128	0.01871
24	0.02905	0.02559	0.02247	0.01968	0.01719
25	0.02743	0.02401	0.02095	0.01581	0.01823

IX

DEPRECIATION

THE BASIC ACCOUNTING documents which reflect the economic situation of an enterprise are the balance sheet and the profit and loss statements, as presented in Chapter II.

Listed in the balance sheet we find such assets as the manufacturing equipment, a building, a truck, or furniture. Such assets did cost a certain amount of money to the enterprise namely the purchase price, to which in some cases an installation cost should be added. Sometimes experience shows that the assets were not worth the price they were paid for. The reverse is sometimes true. A machine can be purchased at a bankruptcy sale for much less than it is worth to the business.

Regardless of such considerations, however, the books of accounts, at the time the asset is being acquired, will always show its *cost* as its value. In other words, the *book value* reflects the accounting transaction (payment of the purchase price and other expenditures related to the purchase either through cash or through a credit recorded in

the "accounts payable" account). Thus the book value does not necessarily reflect the economic worth of an asset.

After a period of use, an asset such as a machine or a building becomes worn. After some years, it becomes worn out and needs to be replaced. It may even happen that assets need to be replaced with new and improved equipment before they become physically unusable. Such replacements are prompted by the need for lowering costs to meet a competitive market. Thus machines that are still physically usable may become economically unusable.

This indicates that, sooner or later, the *opening book value*, i.e., the book value as it was at the time of the acquisition of the asset, needs to be adjusted. Otherwise the balance sheet would become an unrealistic statement.

A similar problem arises with the profit and loss statement. This statement shows the difference between income (from sales and other sources) and expenses. If equipment used by the company is being rented, the rent is listed as an expense. If the equipment is owned by the company, there is no rent to be paid. At the same time, the equipment owned by the company represents a capital investment and it does wear out as it is being used. Unless this is taken into account, the profit and loss statement will also become an unrealistic document, showing an inflated profit that does not take into account the use of the company's assets.

The methods of depreciation are intended to avoid this kind of unrealistic presentation.

The *depreciation expense* is added to the other expenses before determining the operating profit of the enterprise during a given period. This expense, unlike the other expenses, is not balanced in the books of accounts by an entry in the "cash" or "accounts payable" accounts. The reason is that no actual payment is being made to anyone. The depreciation expense is balanced by an entry in the assets account. It amounts to a reduction in the value of the asset concerned equal to the depreciation expense. For this reason, the depreciation expense which involves no cash transaction is called a *book expense*.

Year after year, the depreciation expenses related to a given asset, are added to each other. Their total constitute the *depreciation reserve* of this asset. The balance sheet reflects this accumulation of a reserve by showing for each asset (or group of assets):

- the opening book value; *less*
- the depreciation reserve, which is equal to the total of the depreci-

ation expenses entered in the books of accounts, through profit and loss adjustment, from the time the asset was acquired.

The difference between the two is the *present book value* of the asset (or group of assets).

For example, a plant has been started at a cost of $2,500,000 of investment for machinery and equipment. Each year, a certain amount of depreciation expense (a book expense) has been added to the other expenses. After three years the total of depreciation expenses amount to $500,000. The book value of the balance sheet will then show:

Machinery and equipment	$2,500,000	
Less reserve for depreciation	500,000	
Net value		$2,000,000

It was already noted that the opening value, in this case $2,500,000, did not necessarily reflect the economic worth of the asset at the time it was acquired; however, it did reflect its cost. Except for the fact that there is some question as to what expenditures (such as transportation and placement costs) should or should not be added to the purchase price, the opening book value reflects actual cash transactions. There is no need for an arbitrary decision.

The reverse is true for the net book value. The depreciation expense is not an actual transaction. It is an estimate of the amount needed to make the financial statements of the company realistic by:

1. Adjusting the total expense of the profit and loss statement by adding depreciation expenses;
2. Adjusting the opening book value of certain assets in the balance sheet by deducting these depreciation expenses, the summation of which over the years constitute the depreciation reserve.

The problem is: What should be the amount of depreciation expense each year?

This problem can be analyzed by means of three fundamental questions: *First.* What method should be followed in computing the depreciation expense of each year? *Second.* What are the causes of depreciation? *Third.* What are the general considerations that should be taken into account when deciding as to the length of time it should take to depreciate fully an asset or a group of assets?

These three fundamental questions will now be studied. Special attention will be given to the present trend toward rapid depreciation, which has been the policy of many businesses in recent years primarily

because of the high rate of corporate income tax. The program of "emergency facilities" depreciation, initiated in 1950, and the Internal Revenue Code of August 1954, which has made substantial changes in the rules governing depreciation tax practice, have greatly stimulated this trend.

A. DEPRECIATION METHODS

Although the purpose of the depreciation methods is to narrow the gap between the book value of an asset and its economic worth, it is to be recognized that some variance is to be expected. Actually, if a property is to be sold or mortgaged to secure a bond issue, or its present value needs to be determined for other reasons, an appraisal of its value is made. Such an appraisal is based on current prices as well as on years of use and state of repair. The *present depreciated worth* of the asset is likely to differ to some extent from its *present book value* regardless of the depreciation method that is being followed.

There is no exhaustive list of the depreciation methods that can be used. Certain restrictions result in fact from Federal laws, inasmuch as only the depreciation expenses acceptable to the Internal Revenue Service are deductible from profit for Federal income tax purposes, and as most companies prefer to have a single set of books of accounts rather than to keep one special set for their own use for the computation of dividends and another set for income tax purposes, as they would have the right to do if they so prefer.

The depreciation section of the Internal Revenue Code of 1954 reads as follows on this matter:

SEC. 167—DEPRECIATION

a) GENERAL RULE.—There shall be allowed as a depreciation deduction a reasonable allowance for the exhaustion, wear and tear (including a reasonable allowance for obsolescence)—

(1) of property used in the trade or business, or
(2) of property held for the production of income.

b) USE OF CERTAIN METHODS AND RATES.—For taxable years ending after December 31, 1953, the term "reasonable allowance" as used in subsection (a) shall include (but shall not be limited to) an allowance computed in accordance with regulations prescribed by the Secretary or his delegate, under any of the following methods:

(1) the *straight line method*,
(2) the *declining balance method*, using a rate not exceeding twice the rate which would have been used had the annual allowance been computed under the method described in paragraph (1),

(3) the *sum of the years-digits method,* and

(4) *any other consistent method* productive of an annual allowance which, when added to all allowances for the period commencing with the taxpayer's use of the property and including the taxable year, does not, during the first two-thirds of the useful life of the property, exceed the total of such allowances which would have been used had such allowances been computed under the method described in paragraph (2).

Nothing in this subsection shall be construed to limit or reduce an allowance otherwise allowable under subsection (a).

Generally recognized depreciation methods, including the three methods specifically listed above, will now be reviewed.

It should be understood that they can be applied either to one single asset (equipment or machinery or other property) or to a group of assets considered as an entity.

1. THE STRAIGHT-LINE METHOD

The straight-line method is the simplest and actually the most currently practiced method of depreciation. It is based on the proposition that, if a machine or structure has an estimated life of N years, its value should be written down $\frac{1}{N}$ each year. Accordingly, successive values at the end of each year of use, when plotted against years of life, would fall on a straight line, beginning at first cost and terminating at zero. Thus a machine purchased for $100,000 and having an expected life of ten years would depreciate $10,000 each year. Accordingly, after four years of use, it would have an estimated book value of $60,000.

This method of accounting for depreciation is most generally in use and is a method allowed by the public utility commissions and the courts in determining the costs of power furnished by public utility companies. Some authorities state that, after a machine or structure has completed its estimated life, it still has a scrap value and that this should be included in estimating the annual depreciation. If, for example, a machine costing $50,000 has an estimated life of ten years, and if it is also estimated that it will have a scrap value of $2,000, then the annual depreciation by the straight-line method should be 1/10 of ($50,000 — $2,000) or $4,800. We are inclined to believe that such refinements are not in harmony with the degree of accuracy with which the useful life of the machine may be predicted in the first place.*

* Scrap value may even be negative.

2. THE PRODUCTION METHOD

This method is very similar to the straight-line method, except that it uses production instead of time as the basic unit of measurement. Instead of estimating the useful life of equipment or machinery in terms of time it is estimated in terms of its expected production. For instance, an airplane engine will be depreciated on the basis of its actual flying time as a ratio of this actual flying time to the total number of hours of flight that can be expected during its useful life.

This method is not always considered as acceptable for the purpose of tax deduction. It is sometimes combined with the straight-line method so as to accelerate depreciation whenever intensive usage of the equipment is likely to shorten its useful life which had been originally estimated on the basis of a more moderate usage.

Under the production method, the depreciation expense becomes a *variable expense*. Under any other method, it is a *constant expense*. The straight-line/production combined method, because it makes the depreciation expense partly constant and partly variable, has some distinct advantages. It is not widely used, but in the writer's opinion should receive some serious consideration when selecting a method of depreciation. As far as the writer has been able to ascertain, this combined method was originated at the Bausch and Lomb Optical Company by Mr. Edmond S. La Rose, controller and director of the company. It has been in use for more than twenty years in this company and has been recognized as a highly desirable method of depreciation from many points of view.

3. THE SINKING-FUND METHOD

The sinking-fund method of accounting for depreciation is based on the assumption that each year a fixed sum is to be set aside from surplus and put at compound interest and the total amount of such equal annual sums together with the accumulated interest will equal the first cost, or first cost less estimated salvage value, of the equipment at the end of its expected life. It is the amount set aside each year that represents the depreciation expense shown in the profit and loss statement. Let such an annuity or annual amount set up in the depreciation reserve and put at interest be designated D. Then, if the annual interest is R, the depreciation reserve at the end of each year will appear as follows:

At the end of	Depreciation Reserve
1st year	D
2nd year	$D(1+R)+D$
3rd year	$D(1+R)^2+D(1+R)+D$
4th year	$D(1+R)^3+D(1+R)^2+D(1+R)+D$
5th year	$D(1+R)^4+D(1+R)^3+D(1+R)^2+D(1+R)+D$
Nth year	$D(1+R)^{N-1}+D(1+R)^{N-2}\ldots D(1+R)+D$
	$=D[(1+R)^{N-1}+(1+R)^{N-2}\ldots(1+R)+1]$
	$=D\dfrac{(1+R)^N-1}{R}$

The amount of the depreciation reserve at the end of the Nth year which is at the end of the expected life of the equipment, must equal the original investment or first cost of the equipment which is P. Therefore

$$P=\frac{D}{R}[(1+R)^N-1]$$

whereupon

$$D=P\left[\frac{R}{(1+R)^N-1}\right]$$
$$=P\cdot[\text{sinking-fund factor}]$$

If D is expressed as a percentage of first cost, then the

$$\text{Annual rate of depreciation } \frac{D}{P}=\frac{R}{(1+R)^N-1}$$

Example: A machine has an estimated life of 10 years. What is the depreciation rate when interest is taken at 6 percent?

Answer:

$$\text{Rate of depreciation}=\frac{0.06}{(1+0.06)^{10}-1}$$
$$=\quad 7.6 \text{ percent}$$

Note 1: If the first cost of the machine is \$5,000, what amount is to be set up annually from surplus in the depreciation reserve?

Note 2: If the straight-line method of depreciation had been used, the annual reserve set up would be 10 percent of the first cost, or \$500. The difference between the two methods resides in the assumption that, in the compound interest case, the reserve fund is put at interest, whereas in the straight-line case the assumption is that the reserve fund is idle. As a matter of fact, neither assumption is true. What actually occurs in a majority of cases is that the setting up of a reserve is merely a bookkeeping entry and the

reserve fund is not distinguished from any other funds used in the business and therefore earns whatever percentage the other funds of the business earn.

The sinking-fund method of accounting for depreciation is not used in the manufacturing industries nor in the public utilities except, perhaps, in some unusual cases, examples of which are very rare. It has little practical value.

4. THE DECLINING-BALANCE METHOD

The declining-balance, also called the diminishing-balance, method is based on the supposition that machines and structures wear out faster toward the latter years of their useful life than in their earlier years and hence repairs and maintenance costs in the earlier years are comparatively light. Accordingly, it seems equitable, according to this theory, to charge or write off greater depreciation in the earlier years and less in the late years in order that the sum of depreciation and maintenance and repairs shall be uniform throughout the useful life of the equipment. A method of accomplishing this result is to charge off a constant percentage each year on the *book value* or remaining value. Thus, if a machine is valued at \$10,000 when acquired and is estimated to have a scrap value of \$2,000 at the end of 10 years, the depreciation written off at the end of the first year will be some percentage which will determine the write-off to be established each year such that by its application to successive book value it will reduce \$10,000 to \$2,000 in 10 years and is found from the following formula:

Let $X =$ the constant percentage to be written off each year
$P =$ the initial book value of the investment
$S =$ the estimated scrap value at the end of N years
$N =$ the years of useful life of the equipment.

It can be demonstrated that

$$X = 1 - \sqrt[N]{\frac{S}{P}}$$

The depreciated book value by this method will be, for the

1st year, $P(1 - X)$
2nd year, $P(1 - X) - P(1 - X)X = P(1 - X)^2$
Nth year, $P(1 - X)^N$

This formula is meaningless if $S = 0$; hence, some scrap value must be assumed. This method is sometimes known as the Matheson method. Its use is limited to some features of public utility accounting.

5. THE SUM OF THE YEARS-DIGITS METHOD

This method, as far as the writer has been able to ascertain, was not used prior to 1954. It is sometimes called the Cole method. Its main characteristic is that it makes it possible to write off investments more rapidly than the other methods that are acceptable to the Internal Revenue Service.

According to this method, the amount of depreciation for a given year is:

$$D_U = P \frac{N - (U - 1)}{1 + 2 + 3 + \ldots + N}$$

where

$U =$ the number of years the equipment has been in use (including the one for which the computation is being made)
$P =$ the initial book value of the equipment
$N =$ the years of useful life of the equipment

Applying to the denominator the formula for the sum of an arithmetic progression and presenting the above equation in a more convenient way, it can be written as:

$$D_U = P \frac{N - (U - 1)}{\frac{1}{2} N (1 + N)}$$
$$= P \frac{2(N + 1 - U)}{N(N + 1)}$$

An example will illustrate how this new method accelerates depreciation. Let us assume that equipment costing \$1,000,000 has an estimated useful life of ten years and no scrap value. The depreciation expense for the first year is:

$$D_1 = 1{,}000{,}000 \ \frac{10}{55}$$
$$= \$181{,}818$$

For the second year it is:

$$D_2 = 1{,}000{,}000 \ \frac{9}{55}$$
$$= \$163{,}636$$

For the two first years, then, it is:

$$D_1 + D_2 = 181{,}818 + 163{,}636$$
$$= \$345{,}454$$

or 34.5% of the initial book value of the equipment.

This compares with a depreciation of $\frac{2}{10}$ or 20 percent of the initial book value for the same period under the straight-line depreciation method.

6. THE ACCELERATED-AMORTIZATION PROGRAM

The program of accelerated amortization was started by the 1950 Revenue Act, following the start of the Korean War. Its purpose was to stimulate a rapid expansion of productive facilities required for national defense. The provision was re-enacted in the Internal Revenue Code of 1954 (Sec. 168) which invests the Office of Defense Mobilization with the authority to issue *certificates of necessity.* Upon issuance of such a certificate, any certified portion of the cost of any facility (land, building, machinery, or equipment) can be depreciated over a period of five years instead of over the longer period otherwise applicable to the facility under the ordinary depreciation provisions of the income tax law.

The criteria, as set forth in the Office of Defense Mobilization's regulations, for determining the necessity of facilities are the extent to which the products of the proposed facilities are directly required in defense and defense-related activities in the emergency period, and the extent of any shortage either current or for standby purposes of such facilities. Consideration is also to be given to such other factors as new and improved technology, assurance of fair opportunity for participation by small business, the promotion of competitive enterprise, the competence and performance record of the applicant and the location of the facility with due regard to military security and dispersion criteria.*

According to a Congressional Report recently published, 20,916 certificates of necessity were issued under the accelerated-amortization program between November, 1950, and April, 1956. They covered facilities representing \$36.3 billion of total investment, of which \$21.3 billion were eligible for five-year write-off. This report noted that in

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* O.D.M. Ref 1. Issuance of Necessity Certificates under Section 124A (Section 168 I.R.C. 1954) of the Internal Revenue Code.

the last quarter of 1955 and the first quarter of 1956 the volume of new certifications had increased sharply, reaching during the first quarter of 1956 a total of \$1.4 billion eligible for five-year write-off. It is stated in the report that "*a very large proportion of recent certifications involved such basic industrial resources as electric power generating and transmission facilities and railroad facilities, with respect to which the average useful life for ordinary depreciation purposes is about 30 years. Recent certification percentages have ranged from 35 to 65 percent on electric power facilities and up to 85 percent on railroad facilities.*" The report actually concludes that "*Continuation of the special amortization program may have significantly adverse effects on balanced growth of the economy and efficient use of resources.*" *

7. THE BOOK VALUE OF A DEPRECIATED ASSET

The book value of a depreciated asset is the original investment minus the depreciation reserve. Since the amount of the depreciation reserve may be determined by different methods of accounting for depreciation, it is obvious that the book value of an asset at any time depends on the method used for estimating the depreciation or establishing the depreciation reserve.

a. The book value of an asset according to straight-line depreciation is

$$\text{Book value} = P - DN$$

For example, if the initial book value (P) of the asset is \$10,000 and it is estimated to have a life of 10 years, then

$$D = \$1{,}000$$

The book value at the end of 4 years will be

$$\begin{aligned}\text{Book value} &= \$10{,}000 - (\$1{,}000 \cdot 4)\\ &= \$6{,}000\end{aligned}$$

b. The book value of an asset according to the sinking-fund method of accounting for depreciation is

$$\text{Book value} = P - D\left[\frac{(1+R)^{U} - 1}{R}\right]$$

* Joint Committee on the Economic Report, Memorandum on "Implications of Recent Expansion of Special Amortization Program." May 29, 1956—pp. 1 and 12.

where U is the number of years the asset has been used. But D in turn depends on the estimated years (N) of life of the asset and as has been shown is

$$D = P\left[\frac{R}{(1+R)^N - 1}\right]$$

Hence

$$\text{Book value} = P - P\left[\frac{R}{(1+R)^N - 1}\right]\left[\frac{(1+R)^U - 1}{R}\right]$$

$$= P\left[1 - \frac{(1+R)^U - 1}{(1+R)^N - 1}\right]$$

The quantity in parentheses may be written

$$\frac{1 - \dfrac{1}{(1+R)^{N-U}}}{1 - \dfrac{1}{(1+R)^N}}$$

or

$$\frac{T_{N-U}}{T_N}$$

in which T is known as the *term factor.* Hence

$$\text{Book value} = P \cdot \frac{T_{N-U}}{T_N}$$

This is known as the Benitz Transformation.*

c. The book value of an asset after a given number of years of use according to the declining-balance method is

$$\text{Book value} = P\,(1 - X)^U$$

where U = the number of years the equipment has been in use.

$$X = 1 - \sqrt[N]{\frac{S}{P}}$$

* See Goldman, *Financial Engineering,* Second Edition, page 44 John Wiley and Sons, Inc., New York, 1923. Values of the "term factor T" are given in a table, p. 31, in this book.

$$\text{Book value} = P\left[1 - \left(1 - \sqrt[N]{\frac{S}{P}}\right)\right]^{U}$$
$$= P\left(\sqrt[N]{\frac{S}{P}}\right)^{U}$$

Thus, if the initial book value of the equipment is \$10,000, if its life expectancy is 10 years, and if its scrap value at the end of N years is estimated to be \$2,000, then the book value at the end of 4 years of use is

$$\text{Book value} = \$10{,}000\left(\sqrt[10]{\frac{2{,}000}{10{,}000}}\right)^{4}$$
$$= \$5{,}253$$

d. The book value of an asset after a given number of years of use according to the sum of the years-digits method is:

$$\text{Book value} = P - \sum_{i=1}^{U} D_i$$

where U = the number of years the equipment has been in use
P = the initial book value of the equipment
D_i = the depreciation expense for each of the years included in the period under consideration.

As previously seen in this chapter, the depreciation formula of the sum of the years-digits methods is, for any given year:

$$D_U = P\,\frac{2(N + 1 - U)}{N(N + 1)}$$

N being the years of useful life of the equipment.

Thus the book value is

$$\text{Book value} = P - P\,\frac{2[U(N + 1) - (1 + 2 + 3 + \ldots + U)]}{N(N + 1)}$$

Applying the formula for the sum of an arithmetical progression provides

$$\text{Book value} = P\left[1 - \frac{2\,U(N + 1) - U(U + 1)}{N(N + 1)}\right]$$

Thus, if the initial book value of an equipment is \$1,000,000, and if it has a life expectancy of 10 years, its book value at the end of 3 years of use is

$$\text{Book value} = \$1{,}000{,}000$$
$$= \$509{,}090 \text{ or about } 50\%$$

B. CAUSES OF DEPRECIATION

a. *Normal Use.* There are two principal causes for depreciation of a capital asset or physical property. These are physical and economic. Physical depreciation is evidenced by what is termed the state of repair. If a machine, for example, is kept clean from dust, dirt and grit, its bearings are always well oiled, its worn parts are adjusted or replaced from time to time, it will have a much longer life of physical usefulness than if the above particulars are not attended to. Sometimes machines or pieces of equipment, such as tanks, piping, and valves used in the chemical industries, become eroded in ways which do not permit of repairs. The physical life of such equipment is relatively short and therefore its rate of physical depreciation is relatively high. The decline in physical usefulness under the conditions noted above is frequently referred to as depreciation through normal use, which means the conditions of use which may be anticipated to obtain in the average plant.

b. *Deferred Maintenance.* When property has not been given even ordinary and reasonable care, and when normal repairs and replacements of parts have not been made, an estimate of its value usually provides for neglect of this nature under the heading of "deferred maintenance." This account calls attention to the expenditures which should be made to bring the property up to its normal depreciation value; it is frequently used in railroad accounting. It has been found by experience that a certain sum of money should be spent annually per mile of right-of-way to keep the roadbed in good condition. If the records show that less than this sum was spent in upkeep and maintenance, then the difference between what was actually spent and what should have been spent may be deducted from the surplus as a reserve against deferred maintenance.

c. *Accidental.* Physical damage due to fires or other calamities such as wind storms results in deterioration in value of buildings and machinery which is not predictable but nevertheless must be accounted for. Such accounting is made by appraisal for which no formulated procedure exists. The loss through such damages, if the property is covered by insurance, may be recovered fully or in part, depending on the specifications of the insurance policy.

Causes of *economic* depreciation are the following.

d. *Supersession.* When, through an advance in the arts, a new machine is developed and put on the market, and it operates much more efficiently than other machines used for the same purpose, these other machines used for the same purpose are said to be *superseded.* For example, when steam turbines became generally used, particularly in combination with driving electrical generators, the reciprocating, slow-speed steam engines then in common use became superseded because they were not so economical as steam turbines. Again, if a manufacturer is using a machine which produces 100 units per hour and an improved machine can be purchased which will produce 1,000 units per hour and has an initial cost not much greater than that of the machine now being used, it is obvious that the manufacturer cannot afford to be without the new machine. The one he is using may be in perfect shape mechanically, but from the point of view of its economic usefulness it is said to be superseded. Supersession has nothing to do with the state of mechanical perfection; it is based entirely on comparative economic usefulness. There is no basis for estimating the probability of specific declines in value because of supersession. It may be roughly accounted for at a time of revaluation in case of the sale of property or at the time of merger.

e. *Obsolescence.* Obsolete machinery and equipment is that which can no longer serve a useful purpose. For example, when the fifty-ninth power station of the Interborough Rapid Transit Company in New York City was built, it was equipped with large reciprocating engines. The builder of the engines invested in patterns, jigs, and fixtures, in anticipation of orders for similar engines from other power companies and did not charge their total cost to the building of the Interborough's engines. The steam turbine came into commercial use quite rapidly at this period and no more engines of this type were desired by the power companies. Accordingly, all the expensive equipment of the engine builder for building these engines became obsolete since it could no longer be used for the purpose for which intended. *Obsolescence* arises from the advance of the arts and cannot be predicted. A prudent management, however, operating in an art which is very active would set aside reserves from surplus in anticipation of this contingency. The term *obsolete* is frequently used to describe machinery which has declined in value through supersession, obsolescence, and inadequacy.

f. *Inadequacy.* When a machine, for example, is not of sufficient capacity to accommodate the demands of a growing business and needs to be replaced by a larger machine because a duplicate or an

additional similar machine will not suffice, it must be retired although it may still be in good physical condition and may also be economically usable under other circumstances. The retired machine may be sold to others who can use it, but at a reduced price as a second-hand machine. Suppose a motor is no longer adequate and its depreciated value is, say, $1,000. If it is sold as a second-hand machine at $200, then there is an $800 loss. That is, $800 of its purchase price has not been recovered in costs; it must be written off. The amount that is written off is the amount of depreciation because of inadequacy. This type of depreciation cannot be predicted at the time of purchase and hence can only be handled as it occurs.

g. *An Example.* The principal causes of depreciation of different types of equipment of a telephone company are the ones given in Table XL.

C GENERAL CONSIDERATIONS— THE TREND TOWARD RAPID DEPRECIATION

Up to the time this edition was being prepared, the straight-line method of depreciation has been by far the most extensively practiced method. There are several reasons for this preference. In the first place, since depreciation is primarily a means for accounting for the service cost or the cost of using a capital asset and the estimated life at best is a rough approximation, any refinements in calculation are not appropriate. In the second place, granting that the purpose of the depreciation reserve is often to provide a fund for the replacement of the equipment at the end of its natural life, the change in the purchasing power of money may cause the fund to be insufficient. Again, interest rates may change during the period of accumulation of the reserve. It should also be borne in mind that depreciation reserve is generally not in cash put at interest—as the sinking-fund calculation, for example, assumed—but is usually a book entry indicating a withdrawal from surplus and as such establishes a safeguard against false profits and the payment of dividends from false surplus.

The above reasons, aside from the question of simplicity, have caused the straight-line method to be the most generally accepted one.

In recent years, there has been a trend toward more rapid depreciation. The straight-line method has some limitations in this respect because it is based upon a system of computation that spread the burden of depreciation equally over the whole useful life of the assets. It is possible, for this reason, that such methods as the newly proposed sum of the years-digits method, discussed above, may be more exten-

TABLE XL

DEPRECIATION (TELEPHONE COMPANY)

Causes of Depreciation	Kind of Depreciation (Predictable Effect)	Plant Characteristics Affected	Illustrative Cases
Action of elements	Rot, rust, and decay	Physical condition	Deterioration of wire
Organic agencies	Rot, rust, and decay	Physical condition	Rotting of poles
Use in operation	Wear and tear	Physical condition	Deterioration of autos in use
Injury	Wear and tear	Physical condition	Underground cable injured by pick
Storms and casualties	Wear and tear	Physical condition	Poles destroyed by sleet storm
Improvements in the art	Obsolescence	Function	Substitution of call indicator positions for Manual "B" positions in central offices
Growth of communities served	Inadequacy	Capacity	Substitution of a larger unit, such as switchboard or cable
More intensive service	Inadequacy	Capacity	Substitution of a larger unit, such as switchboard or cable
Fires	Damage	Physical condition	Burning of station apparatus in building fire
Advancing social standards	Public requirements	Character and location	Lines retired due to putting wires of thoroughfares underground
Public convenience	Public requirements	Character and location	Poles retired because of highway changes

sively applied in future years. Its adoption has been strongly advocated.*

It should be noted, however, that the straight-line depreciation also lends itself to a rapid depreciation inasmuch as the management has some flexibility in estimating the useful life of any equipment or machinery. It should further be noted that the Internal Revenue Code of 1954 seems to invite some flexibility as to the methods selected by

* See among others Willard F. Stanley, *New Rapid Tax Depreciation*. Prentice-Hall, Inc., New York, 1955.

providing acceptance for *"any consistent method"* of depreciation [*] and by recognizing the principle that an enterprise can at any time change from the declining-balance method to the straight-line method. It is also indicated that agreements may be reached between the administration and the taxpayer as to the estimated useful life of the property. This may become an important additional element of flexibility in the use of the straight-line method of depreciation. It may also increase the use of the straight-line/production combined method.[†]

In any case, the fundamental problem remains first of all the high-policy decision to be taken by management as to a choice between rapid and slow depreciation. The question is: What practical differences, if any, result from the use of a high or low rate of depreciation?

A very conservative management tends to use high rates of depreciation, resulting in an early write-down of capital assets merely for the sake of safety. On the other hand, high depreciation means high-cost estimates which may be misleading, especially if for this reason a manufacturer may be led to believe that certain contracts offered cannot be taken at a profit, whereas the use of a more reasonable depreciation allowance would indicate that the business could be undertaken at a fair profit.

Another aspect of the question is that the ownership of property often resides in two classes of security interests—the stockholders and the bondholders. The stockholders are interested in obtaining maximum dividend returns and therefore favor a low depreciation charge. The bondholders, on the other hand, are not interested in dividends but are interested in maintaining the value of the fixed assets that are pledged through mortgage as security for the bonds.

A high rate of depreciation favors the bondholder because it tends to maintain the value of the fixed assets. But insufficient depreciation reserve may give a false ratio between the value of the fixed assets and the underlying bonds, and may therefore mislead the purchaser of stocks as to the security of his investment. For this reason, the public utility commissions authorizing the issuance of bonds by public service corporations make diligent inquiry into the value of the physical assets, an important factor of such inquiry being the depreciation reserves maintained or the rates of depreciation allowed. The commissions and the courts, in case the rulings of the commission are appealed, also give serious consideration to the problem of depreciation in the matter of rates or charges for service allowed.

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[*] See above p. 255.

[†] See above p. 257.

Another consideration is that of the rapid technological progresses which in recent years have more and more tended to threaten equipment or machinery with economic obsolescence long before it has reached the end of its physical useful life.

Also favoring the policy of rapid depreciation is the problem of inflation, which changes the value of the economic yardstick, the dollar.* Despite some efforts made to establish depreciation as a means of providing the capital needed for the replacement of a given equipment, it is today well recognized, on the basis of many court decisions, that the investor is entitled only to the recovery of the original capital invested. Accordingly, if the depreciation reserve based on the original investment is not sufficient for replacement purpose, any additional funds required for such replacement must be provided from surplus or from borrowed capital. This is one more reason in favor of rapid depreciation during a period of inflation, which constantly raises the cost of replacing the equipment. The rapid depreciation makes it possible to recover the capital before the money has lost too much of its purchasing power.

Last but certainly not least are the considerations related to the Federal income taxes which have definitely influenced to a great extent the recent trend toward rapid depreciation. With a rate of Federal income tax reaching about 50 percent on most corporate profits it is very tempting for management to follow a policy of rapid depreciation that decreases the taxable profit. Such a policy, as was previously seen in this chapter has been encouraged in recent years by Federal legislation and administrative practice. The main reason for this encouragement is that it is considered that a rapid rate of depreciation encourages capital investments in new equipment and machinery and thus stimulates the national economy as a whole.

Against this point of view, it has been said that from the point of view of tax liabilities the rapid rate of depreciation creates a dangerous illusion because it merely postpones the payment of taxes that will become due after the rapid depreciation period is over while the equipment is still being used although fully depreciated.†

One of the arguments in favor of the new sum of the years-digits method is that it results in a very rapid depreciation and yet provides at the same time a transition period that the straight-line method does not provide if and when applied with the intention of depreciating equipment or machinery over a period shorter than the actual useful

* See Chapter XIV.

† See above, p. 262, note 1.

life of such equipment or machinery can reasonably be expected to be.

In spite of such arguments it can be expected that in the years to come the straight-line method will continue to be widely accepted by industry as a method of depreciation because of its simplicity and because of its consistency year after year which makes it especially well adapted to the procedures of budgetary control. It is conceivable that in the years to come the straight-line method may be applied with a greater flexibility. One element of flexibility may result from the approach followed in estimating the useful life of equipment or machinery on the basis of its technical characteristics and in the light of expected technical progresses.* Another possible development may be a more widespread use of the straight-line/production combined method. This combined method may well provide a much needed equilibrium between too slow and too rapid depreciation.

* For the use of statistical methods in estimating the average service life of a group of equipment or machinery, see E. L. Grant and P. T. Norton, *Depreciation*. Ronald Press, 1956, Chapt. 5.

X

PRINCIPLES OF EXPENSE CLASSIFICATION

IT IS WITHIN THE MEMORY of many of the older generation that a businessman after taking inventory at the end of the year and adding his expenses was not until then able to learn if expenses were less than income and what if any profit was made during the past year. Due to the work of accountants and industrial engineers in the field of cost accounting, expense control, and the economics of the business process, due also to the use of various tabulating and computing machines that have fundamentally improved the conditions of clerical work, the modern businessman has now available to him a vast fund of knowledge and wealth of techniques concerning the expenses of all types of business enterprise. Through this knowledge of the nature and character of the expenses of all phases of the business process from financing operations to marketing the product, the businessman can not only keep himself currently informed about the expenses of his business but he can estimate the probabilities of the expenses of a proposed undertaking.

I. CATEGORIES AND CLASSES

One of the basic steps in establishing a knowledge of expenses and providing a technique for their control is the establishment of categories and classes of expenses. Upon such categories and classes, the system of accounting is designed so that every penny of expense may be properly accounted for in accordance with the purposes and needs of the business. Accounting for expenses for profit estimating purposes is, of course, only one of the problems encountered in both large and small businesses. In addition, businesses of moderate and substantial size face two other problems of expense accounting which the small businessman does not find too difficult to handle and these problems are: (a) the determination of the cost of a product or a process, and (b) the measurement of each executive's efficiency.

It is comparatively easy in a small shop manufacturing one product only to find the cost of each unit produced. The unit cost in such a case is equal to total expense divided by the total number of units produced.

In such a business, there will usually be one or, at most, a few executives who keep constantly in touch with each other. Each of them is well acquainted with the others' activities, being probably able to interchange places if need be. There is no problem of "measuring" each executive's efficiency.

The situation is entirely different in large, modern industrial corporations or even in middle-sized businesses manufacturing several lines of products and managed by a substantial number of executives.

Let us take, for example, a middle-sized business which has two plants and a central administrative office, and manufactures bicycles in one plant and typewriters in the other. Should the telephone bill of the headquarters be considered as a cost of manufacturing the typewriters or as a cost of manufacturing bicycles or partly one and partly the other—but, then, in what proportion?

Let us take again the same business. The profit and loss statement shows a profit. Does this mean that Mr. Smith, the chief of maintenance in the bicycle plant, could not spend less money? How can we know?

Some expenses are obviously incurred in the manufacturing of bicycles, while others are obviously special to the manufacturing of typewriters. They can be directly assigned to each line of product. Such are raw material expenses, for instance, or parts bought from a contractor—the tires and tubes of the bicycle, the ribbons of the type-

writer. But even for them, or at least for many of them, the question of responsibility arises. If, for instance, fifty tubes a week are punctured while being mounted, should this waste not be charged to Mr. Thompson, who happens to supervise the department where tubes and tires are mounted on the wheels?

Other expenses are even more difficult to handle. A salesman may sell both bicycles and typewriters. His expenses must be allocated to each line of products. Also, the selling expense cannot be considered only as a whole since the sales manager for the West Coast district would not want to be held responsible for total sales expenses, including expenses of the New York district and of many others over which he has no authority.

Such examples show the complexity of determining the cost of a given product delivered to the customer and of measuring an executive's efficiency.

Cost accounting endeavors to solve such problems. It is not intended to enter here into the details of modern cost accounting technique, but only to give general guiding principles in the two main steps of cost accounting, namely, expense classification and expense allocation. The present chapter deals with expense classification, the following one with expense allocation

Every classification is arbitrary, and has no meaning in itself. Its only value is in its final purpose. A paper manufacturer will classify his products according to their quality and weight because his purpose is to sell each quality at a certain price. The same sheets of paper, after they have been used for writing letters or printing books will again be classified but according to entirely different standards, such as, name of the author, content of the letter, size of the book, etc. Each standard of classification is justified if and when it serves well its own purpose. None is perfect, because every classification implies the preference given to certain characteristics, thereby ignoring other characteristics which, usually, have also their importance. If letters are filed according to the names of the authors, it will take time and effort, later on, to find those concerning a given subject, or referring to a certain period, or to a certain geographical district, etc. One solution is to file one copy of the letter alphabetically, one chronologically, one geographically, etc. But practical considerations prohibit the extensive use of such a solution.

Expense classification does not escape the limitations of all classification, in that it also is arbitrary and far from perfect. It may be improved by refining, but refinements in cost classification are also

limited by practical considerations. The experience of many businesses shows that it is useless to recommend a cost system that will cost more to operate than the money it can possibly save.

Since conditions vary with each business enterprise, it is impossible to say, in general terms, how refined a cost classification should be. In this chapter we will study the generally accepted classification of expenses into *manufacturing expense, selling expense, administrative expense*, and indicate in what directions refined sub-classifications can be and, in fact, are attempted.

As a general introduction to the subject, it may be said that expense classification, just as every other classification, has no other meaning than that of its purposes. We must continually remind ourselves that the ultimate purposes of expense classification are:

1. To determine the cost of a product or process
2. To measure executive efficiency.

An expense classification that does not serve one or both of these two purposes is unjustified. An expense classification that, directly or indirectly, costs more to operate than the money it is intended to save is unjustified.

II. MANUFACTURING EXPENSE

There are three principal divisions of effort in the manufacturing industries, and these are:

1. Manufacturing the product
2. Selling the product
3. Administering the business.

To these divisions of effort correspond the generally accepted, and practically useful, functional divisions of expenses in:

1. Manufacturing expense
2. Selling expense
3. Administrative expense.

The manufacturing expense is the expense incurred during the third phase of the economic flow chart (conversion by manufacture).*

The economic flow chart outlined in Chapter I shows that for the manufacturing industries there is a flow of values in the third phase (conversion by manufacture) which results in the value of the prod-

* See Figure 1, page 10.

uct. It also shows that the flow is along three main channels: equipment, materials, and services.

How the "values" in equipment, materials, and services flow into the "value" of the product can be understood by examination of the nature of this value conversion process. The equipment used in manufacture consists of buildings and machinery and may be considered as permanent in the sense of use for a long continuing period of time. This equipment, such as a particular machine tool, may be used for a productive operation such as grinding or milling. Other equipment, such as used in the factory office (furniture, typewriters, etc.) and in the power plant (boilers, generators) and in other service departments, finds its use value reflected in the cost of the service in which it is employed. The values which flow through the materials channel are reflected in the cost of the material of which the product is made. Other materials used in the service departments find their values in constituting part of the service costs.

The values which flow into the product through services consist in general of:

1. Labor at productive operations
2. Labor in service departments
3. Power, heat, and light
4. Other service subsequently stated in more detail.

For purposes of accounting for, or measuring the flow of values to any particular product, it is generally convenient to group the elements of the conversion by manufacture into certain functional groups as items of cost, which will now be defined.

1. THE ITEMS OF MANUFACTURING EXPENSE

A. *Materials Cost.* This is the cost of the material which enters into and becomes part of the product. This is to be distinguished from the cost of those materials which are consumed or used during the manufacturing operations, such as oils, waste, taps and dies, coal, water, gas, etc. The cost of these materials is not part of materials cost, but is an item of factory overhead.

It may be asked, however, what constitutes the items of this cost, for, unless this is known, the term is still inexact. The cost of materials consists of the purchase price, plus freight and trucking charges incurred in conveying them from the place of purchase to the storeroom in the factory. This is the real cost of the material. However, it

is not always convenient to apply freight and handling charges to specific materials, particularly when freight, express, and trucking bills include miscellaneous materials delivered. Accordingly, materials cost, for practical purposes, is often taken as the purchase price, and the handling charges are listed as items of the factory expense.

While this method of determining the cost of materials is not strictly accurate—for, in reality, the cost should be based on all items of expense incurred in bringing materials to the point of use—at the same time, the additional expense of clerical service necessary to the allocation of freight and express charges may not be warranted. If, however, such charges can be easily determined, it is well to include them as items of the cost of specific materials. Sometimes such charges will be added in the form of "standard costs" to avoid the difficulty.*

Another and even more fundamental difficulty arises when the "purchase price" is considered. If a plant carries a substantial inventory of raw material, and if it takes a substantial length of time between the time the raw material is purchased and the time it is processed, the purchase price of the raw material being processed may be difficult to determine, because of the possible fluctuations on the commodity markets.

* In its annual report to the stockholders for the year 1946, the Westinghouse Electric Corporation describes in detail its extensive use of "standard costs." As this description is of general interest, it is reproduced hereunder for the benefit of the reader. (This description is also related to the use of standard cost in the evaluation of labor cost and factory expense, which are discussed in the following pages.)

Basis of valuation: The majority of the material is priced at standard cost, which cost is based upon the average purchase price or estimated market price over a period of one year or longer; other material is valued at actual cost. Material price variation reserves are provided to adjust standard cost to actual cost. Where adjustment to replacement market value is necessary, the gross value of each class of inventory is adjusted to that value.

Under the companies' accounting policy the direct labor cost is based principally upon allowed standard time limits for performing processing operations, valued at normal standard hourly labor rates; other labor is valued at actual cost. Direct labor variations from standard are absorbed in operations currently.

Under the companies' accounting policy the indirect manufacturing cost is based upon costing rates per allowed standard time limits which, under normal productive activity, are intended to absorb fully the indirect manufacturing expenses, including depreciation, under normal operating conditions. The variation between the amount of indirect manufacturing expenses charged to inventories in accordance with said standard time rates and limits, and the actual indirect manufacturing expenses, is charged or credited currently to the cost of goods sold, except that a reserve is provided for that portion of the expenses over-absorbed and included in inventory values due to factory operations being above normal.

Shall we say that the "purchase price" of the material being processed will be, for accounting purposes, the average of the actual prices paid for the various lots of material that have been purchased during a given period—the year, for instance?

Or shall we say that we will assume that the material bought first is being first processed?

Or shall we, on the contrary, assume that the most recently purchased material is being first processed?

Or shall we endeavor to identify the raw material used and to assign to each lot manufactured the actual purchase price paid for the material actually used?

In fact, all those methods are being used. They are respectively known by such names as the "Average Cost," "First-In, First-Out" (FIFO), "Last-In, First Out" (LIFO), or "Identified Lot Cost" methods of inventory valuation.

For a detailed study of each of these methods, of their respective advantages, and their impact upon the income tax liabilities of a company, the reader is referred to textbooks on cost accounting and controllership.

B. *Labor Cost.* This consists of the wages paid to those workmen who are engaged in specific productive operations or who are in control of specific processing operations. The wages paid to the workmen operating a milling machine or a band saw or a power hammer, for example, are labor cost. The wages paid to toolmakers, storekeepers, and others who render important service in the factory are not labor cost but part of factory overhead. The reason for this distinction is that the labor applied to specific units of work bears a direct relationship to the number of units of work accomplished within a given time period, and therefore the cost of such labor is a prime factor in the unit cost of production. On the other hand, the cost of service labor cannot be directly associated with the quantity of a specific unit of product manufactured during a given time period, and it must be accounted for by methods of indirect association with the work of production.

Labor cost is sometimes termed *direct labor*, and the wages paid to these rendering general service in the factory are frequently specified as *indirect labor*. The term productive labor is also used for direct labor; and non-productive labor is synonymous with indirect labor. Non-productive labor, however, is not a good term, because it implies that such labor is in the nature of a necessary evil, whereas it is, in

fact, frequently the most important and useful labor in the sense of effecting a low cost of production.

C. *The Prime Cost.* This item is the sum of materials cost and labor cost.

D. *Factory Overhead (also called Factory Expense).* The total of all expense, other than materials cost and labor cost as above defined, incurred in the *possession* and *operation* of the factory comprises this item. It does not include the expenses of selling or managing the general affairs of the business. The possession of the factory occasions the expenses of taxes, insurance, and depreciation. The operation of the factory requires the services of management, supervision, storekeeping, cost keeping, toolmaking, boxing and crating, and many others, and also incurs expense for heat, light, and power. A list of factory overhead items would therefore include:

1. *Indirect Materials.* In the operation of every plant, quantities of material such as oil, waste, brooms, files, belting, and other supplies are used; furnaces must be relined, boilers retubed, broken windows glazed, and the general "housekeeping" of the whole plant looked after. The cost of these materials, worn out or used up in the operation of the factory, is not specially associated with any definite product or process, but the expense is necessarily incurred by the operation of the plant as a whole, and is spread over all processes and products.

Sometimes it is convenient to group indirect materials costs under several different heads, in order that the whole cost of any service department, as distinguished from a processing department, may readily be determined. All indirect materials used in the power plant in its maintenance and repair might be listed as materials costs, power plant maintenance; whole materials used in repairing the building may be listed under the item of building maintenance. Accordingly, any detailed operating statement will usually not show all indirect materials cost under a single heading.

2. *Indirect Labor.* Two general classes of labor are employed in a factory: direct labor employed at productive processes, and labor employed in the service departments. Such labor may be skilled or unskilled. Indirect labor employed in the toolroom, for example, will be skilled—sometimes more highly skilled than the direct labor employed in processing. But it is not generally possible to associate the wages paid to the men in the toolroom with particular products being made in the plant, because the results of their work are so broadly

applied to factory output as a whole. The labor employed in moving materials about the plant is unskilled and indirect. Checkers, inspectors, timekeepers, and all others whose duties lie in similar fields are employed in so-called "service" departments, and their labor is all indirect. Like the analogous costs of indirect materials, the cost of indirect labor may not appear in the operating statement as a single item, but may be associated with a number of separate departments of operation or service, according to convenience or usefulness in management.

3. *Power, Heat, and Light.* All costs incurred in the provision and maintenance of this class of service are chargeable to factory expense, and will include wages paid, fuel consumed, and such items as insurance and depreciation, just as if the power plant were a separate industry by itself. Practice in accounting for the cost of power, heat, and light varies considerably. Sometimes insurance and depreciation are not included, but appear under the general heading of insurance and depreciation for the entire plant. Therefore it is always necessary, in comparing the power costs of different plants, to know how these costs have been itemized. Sometimes it is good practice to omit insurance or depreciation from the accounting of specific service departments, such as the power plant, and include such items in the accounts of the factory as a whole. The point is: When such is the case, be sure to *know* it when making any study of the situation.

4. *Insurance.* This is a service rendered by society. People contribute to a common fund for the purpose of helping one of the group who may suffer misfortune through fire or other calamity. The cost of this service is a factory expense due to the possession of the factory itself.

5. *Taxes.* The service rendered by the community to its members is paid for by taxes. Protection against fire, police protection against theft and riot, and other municipal services are paid for through taxes. This is properly chargeable to the possession of the factory.

6. *Depreciation.* All wear and tear of machinery and buildings must be charged to factory expense, since it is caused by the possession and operation of the factory, and is just as much a cost of producing an article as the cost of the material of which it is composed, or the labor employed in shaping it.

7. *Service Department Costs.* The departments of operation of a factory may conveniently be divided into processing departments and service departments. Toolrooms, storerooms, shipping and receiving departments, drafting rooms, shop offices, yard gangs, pattern shops,

etc., are all service departments; and the costs of operating these various activities are chargeable to factory expense.

E. *Manufacturing Expense.* This is the sum of materials cost, labor cost, and factory expense. In preparing the profit and loss statement, the accountant often reports this item as the *cost of sales*, meaning thereby the cost of manufacture of the goods sold.

The classes of cost defined so far account for all those incurred in *manufacturing a product* and preparing it for shipment, ready for delivery to the customer. To obtain a clear picture of how these cost items accumulate as a product is being manufactured, we must examine more closely a typical manufactured product and trace the progress of its parts through a typical factory. For purposes of illustration we will select a mechanical product such as a lawnmower and consider what happens in the manufacture and assembly of its parts.

2. THE MANUFACTURE OF A MECHANICAL PRODUCT

In the first place, we find that the product consists of many parts. Some of these parts, such as bolts, gears, keys, and rubber tires may be purchased as finished parts from other manufacturers. The remaining parts are produced from raw materials. Each part must pass through a series of processes of milling, drilling, grinding, or other operation to convert it from raw material to a finished part. The finished parts must be assembled. This may proceed by assembling certain parts belonging to a unit of the machine and then assembling these units to form the complete machine. The problem posed in cost finding is to determine how much it costs to perform each operation on each part, how much it costs to assemble the parts into units and how much it costs to make the final assembly of several units into the completed product. Let us now look at the factory. Here we find that some of the parts are processed by the use of very costly machine tools while other parts are worked on at a bench with hand tools. A given part may start in Department A, for example, which is very costly to maintain; next to be worked on in Department B, which does not cost very much to operate; and eventually be finished in Department C, which again is costly to operate. The wage rates, the costs of power, tool service and inspection, to mention a few items, may vary among the departments. If, then, the increments of cost which a given part accumulates as it moves from department to department on its way to final form are to be determined, it appears that the factory expense must be determined for each department of manufacture. This

means that the total of the factory expense for the entire factory must be considered as made up of the sum of the factory expenses of the departments. It also appears that some method must be found for recording the labor cost on each part as it is worked on in each department. The net result of these observations is that each department of manufacture must be dealt with as though it were a miniature factory and all the costs of operating each miniature factory must be assessed to the parts which pass through it.

This will enable us to know the total cost of manufacturing the product. At the same time, it will also enable us to determine the actual expense for which the heads of each of these miniature factories are responsible.

There is another aspect of the organization of a factory which needs to be understood if a clear picture of the problems of finding the production cost of a given product is to be had. Upon visiting a factory we find that it is organized on the basis of production departments and service departments. The productive departments may consist of:

a. A foundry for making castings of parts, later on to be machined
b. A milling department where all milling operations are performed
c. A drilling department where all drilling and tapping operations take place
d. A lathe department where turning operations are performed
e. A plating department where parts are electroplated
f. A polishing department where parts are polished after plating
Etc.

In a small factory, departments b, c, and d, listed above, may be combined in one department for general machine work. In a large factory, the productive departments may be organized on the basis of products made, and again subdivided into smaller components, such as a department for the manufacture of complete parts of a given kind, such as armature winding in a factory manufacturing motors, or a department in which all armature and field coils are impregnated and baked. However the production departments may be organized either in a small factory or a large one, there will always be found a number of service departments organized to render service of a particular kind to all the production departments.

Such service departments may be:

a. A storeroom or a series of storerooms for raw materials, parts partly processed, and furnished parts and complete products

b. A toolroom where all special tools, gauges, and fixtures are made and kept in repair

c. A pattern shop where wooden or metal patterns are made for use in the foundry

d. A tool crib where the tools are stored and from which they are distributed to the production departments as needed

e. A scheduling and dispatching office where the flow of work through the shop is controlled

f. A drafting department where the parts are designed and blueprints are made for use in the production departments and for some service departments, such as the pattern shop and toolroom

g. An accounting department where cost records are kept

h. A purchasing department

Etc.

Furthermore, we find some service departments are used not only by the production departments but also by other service departments. The power plant, for example, furnishes heat, light, and power for all departments, both production and service. The accounting department, the purchasing department, and the office of the works manager serve both the production and service departments of the factory. There appears in this whole set-up an intertwining of the flow of values, the detection of which seems at first to be impossible. How may these many costs of running a factory be brought under control so that some reasonable accounting of their relation to the parts and final product may be made?

It is the factory expense element which seems to be the troublesome one, since the materials cost and the direct labor cost can be readily associated with the processes performed and the product made. The problem then is one of allocating the elements of cost—materials, labor, and factory expense—to the parts and final product, as will be studied in the next chapter.

III. SELLING EXPENSE

The expense of all activities which are engaged in marketing the products and promoting their sales, together with the costs of the supplies and equipments used in such activities, constitute the selling expense. The usual classifications for such expense are:

A. Salaries—executives, salesmen, other employees

B. Commissions

C. Advertising by television, radio, newspapers, catalogues, and other media

D. Office expenses for telephone service, telegraph, office supplies, clerical services, etc.

E. Promotion expenses such as entertaining, convention displays

F. Traveling expenses for sales solicitations, consumer contacts, etc.

G. Rent of offices, branch offices, display rooms, warehouses, etc.

H. Delivery expenses

I. Trade association expenses

J. Bad debts.

The classification of selling expense items, and their subclassifications for any particular business, is controlled by the purposes such classifications may serve in arriving at equitable allocations which (1) permit the determination of the expense of distributing the products to the customers in all territories and in all groups (wholesale, retail, export, chain stores, etc.) and (2) enable the management to measure the efficiency of selling executives and of marketing procedures. Some indication of appropriate selling expense classification for a particular type of marketing situation was given in Chapter VII. Other situations demand classification of the items of selling expenses based on the kinds of activities engaged in and the general trade practices inherent in each type of market.

IV. ADMINISTRATIVE EXPENSE

The items of this type of expense usually include:

A. Salaries of the president, vice presidents, secretary, treasurer; except as such officers, a vice president for example, may be in charge of marketing or of manufacturing. (In the latter event salaries and associated expenses of their offices are usually classified under the departments they supervise.)

B. Salaries of all employees in administrative offices

C. Supplies and other office charges such as typewriter and data processing equipment

D. Rent, insurances, taxes, heat, light, power chargeable to administrative quarters

E. Traveling expenses

F. Legal expenses

G. Financing expenses.

The division between administrative expense and selling expense is not always clear in certain types of expenditures. If, for example, the president of the company divides his time between general administrative duties and maintaining contacts with important customers with whom he may contract for their annual supply of the company's products, it is not always apparent what part of his salary and traveling and office expenses should be charged to sales or to administration. Many administrative officers and their staffs often divide their activities among the various divisions of the business with the result that the expenses associated with their activities can only be classified in categories which permit of periodic review as to their variation in time, that is, month by month. The items of administrative expenses cannot be identified with any of the processes of manufacture nor other prime activity of the business since there is no functional or cause-and-effect relation between such expenses and these activities. Who can tell, for example, what the economic effect of a discussion on manufacturing policy with the president of the company may be on the costs of production? Administrative expense items therefore are classified in such categories as will permit of periodic review of their variation from established patterns. The consequences of such variations are not usually measurable, and therefore control of such expenses cannot be held to the same scientific accuracy which attends the control of other expenses such as manufacture, for example.

V. SUMMARY

The elements of the cost of manufacture are shown graphically in Figure 58.

To recapitulate, for convenient reference: The several elements of cost may be grouped as follows:

A. Materials cost—The cost of materials entering into and becoming part of the product as sold

B. Labor cost—The cost of labor which can be directly associated with a specific product or process

C. Factory expense—All costs other than direct materials and direct labor which are occasioned by the possession and operation of the factory

D. Selling expense—All expenses incurred in marketing the product

E. Administrative expense—All expenses incurred, other than manufacture and selling, in managing the general affairs of the business.

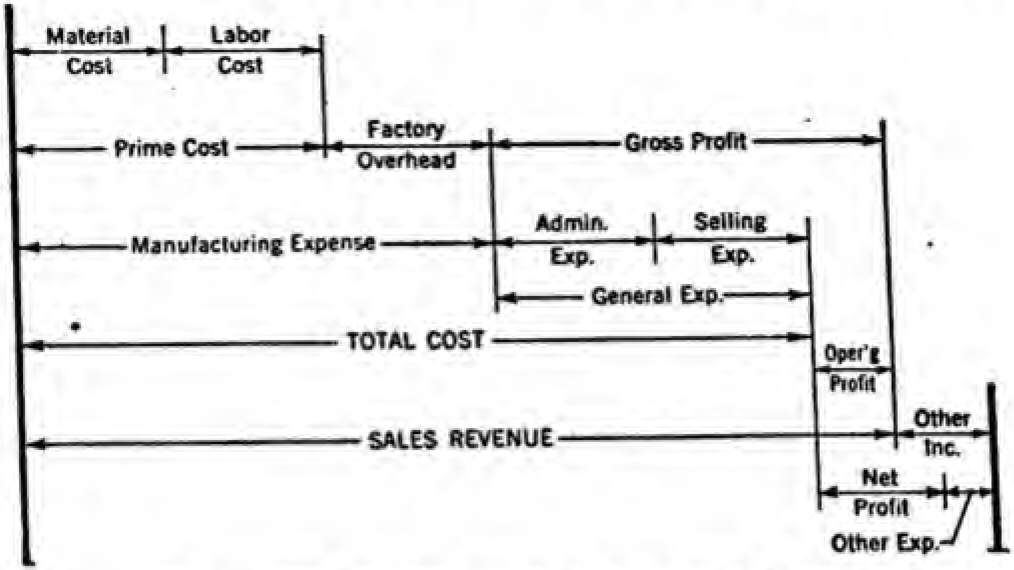

Figure 58. The Elements of Cost in Industry

Typical items of *factory expense* are:

1 Indirect labor
2 Indirect material
3 Superintendence
4 Heat, power, and light
5 Toolroom
6 Maintenance and repairs
7 Building and grounds
8 Insurance
9 Taxes
10 Depreciation

Selling expense includes:

1 Salaries
2 Traveling
3 Advertising
4 Conventions
5 Commissions
6 Telephone and telegraph
7 Supplies and postage

Administrative expense may consist of:

1 Salaries
2 Traveling

3 Legal
4 Telephone and telegraph
5 Supplies and postage
6 Data processing equipment

Prime Cost is the sum of materials cost and labor cost.
Manufacturing Expense is the sum of prime cost and factory overhead.
Total Cost is the sum of manufacturing expense, selling expense, and administrative expense.

XI

PRINCIPLES OF EXPENSE ALLOCATION

EXPENSE CLASSIFICATION may be likened to the assembling of documents of like characteristics in one folder. Not until the folder is properly filed can it be said that the filing of the documents is completed. So also expenses after they are *classified* must be *allocated* in a properly designed system of cost accounting before the purposes of classification have been fulfilled. Such a properly designed system of accounting will provide that the same operation will allocate the expense to a product or a process (determining the cost of the product or process), and to a department or division of the business (determining executive responsibility and efficiency).

To illustrate this procedure, let us take the case of a business manufacturing four types of products designated by 1, 2, 3, and 4, and assume that there are five executives to be known as A, B, C, D, and E, who are responsible in their respective spheres for all the expenses of manufacture. The cost accounting system should provide for the

classification and allocation of all items of expense in such a way that the cost of each product is determined and the expenditures controlled by each executive are assembled. Each product's selling price may then be compared to its cost. The executives' performances may be measured and compared, and their efficiencies ascertained. Under such a system of expense classification and allocation, a tabular statement of the following nature may be set up (Table XLI).

TABLE XLI

COST ALLOCATION DIAGRAM

	Product 1	Product 2	Product 3	Product 4	
A					Total Executive A
B					Total Executive B
C					Total Executive C
D					Total Executive D
E					Total Executive E
	Total Product 1	Total Product 2	Total Product 3	Total Product 4	GRAND TOTAL

Each dollar spent in the business should be so classified and allocated that it eventually finds itself in one of the above spaces. By adding the figures in the spaces vertically, the cost of each product is found. By adding horizontally, the total expenditures made under the supervision of each executive are determined. The sums of the vertical and horizontal totals are equal to each other and equal to the grand total (cost of operation). It must be noted, however, that there are some expenses such as rent, depreciation, and taxes, which, for accounting purposes, are assigned to certain executive categories, although the executive can not be held responsible for their amounts. Accordingly, the spaces in the above diagrammatic presentation of the idea of classification and allocation must be further broken down so that the column at the right (executives' totals) will consist of two parts, one assigned expenses, and the other the amounts for direct labor, supplies, etc., spent under his control. It is this latter amount for which the executive is held accountable and which may be used for the measurement of his efficiency. Modern accounting practice provides for the break-down of expenses by executives as above described so that direct accountability for expenses under any executive's control may be required. This is necessary for purposes of budgeting.* *The*

* For a more extensive discussion of this subject and a presentation of the method of subclassification in "*general accounts*" and "*departmental accounts*," see Villers, *The Dynamics of Industrial Management*, pp. 237*ff* and 444*ff*.

above pattern of expense allocation is intended to illustrate simply and diagrammatically the general problem of allocation organization, and is not intended to create in the reader's mind the dangerous illusion that the treatment of expense data is simple and the problems of production cost and executive efficiency are easily solved. On the contrary, it should be clearly understood that the matter of cost accounting is one of the most complex faced by industry. It is not intended here to do more than to develop a few general principles that may serve as an introduction to a study of cost allocation.

I. PATTERN VARIATION

The application of such principles will indeed vary with the type of business under consideration, as the example used for illustration, taken from practice, will clearly show.

There are, in general, three types of business distinguished by the character of their processes of manufacture or the character of their business activities. These are:

A. The process industries

B. The materials fabrication industries such as machine shops

C. The compound businesses, such, for example, as those which both manufacture equipment and contract for the installation of such equipment, and also sell it to others who do the installing.

A. THE PROCESS INDUSTRIES

In these businesses, the manufacturing divisions of which consist in the processing in bulk of given raw materials such as sugar, paper, cement, yeast, leather, glass, and like products, it is necessary to know the costs of each process or each group of like processes in order to devise effective economic control of production as a whole. Unless costs by processes are ascertained, it will be impossible to locate the causes of the rise or fall of expense in any given period compared to a prior period. Therefore, the correct determination of costs by processes is important in such industries. Direct material costs are easily determined for such industries. Direct labor does not have the significance it has in the metal-working industries, where economy of production is in some measure dependent upon the efficiency of labor itself, and upon the management of such labor. Accordingly, the direct labor item is not determined by the direct labor timecard method, but is associated with the processes at which the

labor is engaged. In this respect it is handled like any item of factory expense.

It will also be noted that direct labor does not have the same control on output as it has in some other industries. When labor is required to attend an operation which is conducted for, say, six hours, at a temperature of a given amount, there is nothing labor can do to hasten or delay the operation. Furthermore, the wages paid to labor are applied to the same material batch after batch (if the batch method of operating is used), or to the whole material produced in the period of operation.

The accounting for labor costs is accomplished by direct apportionment to the process at which it is employed. The factory expense, however, presents a different problem, for it is not usually apparent how much power, steam, water, gas, or other items of factory expense are consumed or occasioned by one process or another. It is only after a careful analysis based on measurements that any reasonable apportionment of factory expense to processes can be accomplished.

The first step in such an analysis is to prepare a *flow sheet* of the processes. This is a statement, usually in graphic form, of the sequence of primary processes, together with those companion thereto, through which the materials pass from the raw state to the finished product.

The next step is to block out, on the floor plans of the plant, the space occupied by each process and identify each piece of machinery and equipment used in conjunction therewith.

The third step is to determine the amount of fixed charges, such as depreciation, insurance, and taxes, associated with each process, and the amount of proportion of variable charges, if they are applicable to several processes, which each process occasions. The mechanism of the accounts may then be set up so that the total factory expense in any month may be apportioned to the proper processes. Monthly comparisons of these costs and the details thereof will then reflect the influence of changes in operation conditions or policy, and thus serve in the guidance of future operations.

B. THE MATERIALS FABRICATING INDUSTRIES

Industries such as machine shops are sometimes referred to as mechanical manufactures. Such plants, in general, may be regarded as made up of two classes of departments. One class of departments in metal-working plants, for example, consists of machine shops, foundries, and assembly shops. Such departments or shops are engaged in

forming or shaping or otherwise treating the product. In this sense they may be termed *productive departments*. Other departments exist to render service to the productive departments. Such departments are toolrooms, pattern shops, power plants, repair shops, etc. These may be termed *service departments*. When the productive departments are quite different in character, and when all the products do not pass through all the productive departments, it becomes necessary to treat each productive department as if it were, in a sense, a separate manufacturing plant. This demands that each productive department must carry a separate factory expense. Accordingly, therefore, it must be determined to what extent, from the standpoint of expense, each service department serves each production department and also what amounts of factory expenses such as taxes, insurance, depreciation, and other items are directly incurred by each production department.

C. COMPOUND BUSINESSES

Very frequently the business of a company involves not only the manufacture of machinery, equipment, or materials, but also the installation of the machinery or equipment or the application of the materials to construction work. Under such circumstances the company is engaged in both manufacturing and contracting. It very frequently happens that such companies not only contract for the installation of the machinery or materials which they manufacture, but they also sell their products to others, who in turn act as contractors for such installations. A manufacturer of composition flooring materials, for example, may also take contracts to lay floors in hospitals, office buildings, and public buildings in the community in which the factory is located, as well as sell the products of the factory to flooring contractors in distant cities.

Manufacturers of small ammonia compressors for refrigerating purposes usually take contracts for the installation of small refrigerating plants and, therefore, maintain a force of men for the installation of equipment over a considerable territory. For this purpose, also, the manufacturer may operate a "pipe shop" to make the coils and condensers which together with the compressors constitute the principal material for the installations. He may also sell his compressors through resale agents who have their own "pipe shops" and take contracts for installation.

Manufacturers of fabricated steel for building purposes, particu-

larly for building alterations and extensions, so many of which exist in and nearby our larger cities, frequently maintain a warehouse of structural shapes from which they withdraw materials for use in their own fabricating shop on contracts which they have taken, and from which they also sell structural shapes to builders who cannot afford to carry a large inventory of steel shapes. The owners of such an enterprise may be in the fabricating business, the warehousing business, and the contracting business.

A certain well-known manufacturer and distributor of watches produces in his own plant only 40 percent by value and 20 percent in number of the watches sold by the company. His principal business is, therefore, the merchandising of watches. Any number of similar examples might be given in illustration of the fact that many business enterprises, though apparently manufacturing, are in reality based upon or concerned with other operations as well. They are, therefore, essentially "compound businesses" conducted by a single organization. Any analysis of the economic characteristics of such a business as a whole must be based upon an analysis of the economic characteristics of each component thereof. In like manner the economic operation of a power plant as a whole can be accomplished only by a proper control of each unit of the plant, and this control can be effected only when the performance characteristics of each unit are understood.

A company operating a compound business must therefore have regard for the following principles:

1. All items of factory expense must be apportioned to the "independent enterprises" according to the responsibility of each.

2. The total of the *portions* thus found should constitute the total factory expense for each respective industry. Thus A percent of factory expense by the business as a whole is the factory expense of the compressor shop; B percent for the pipe shop; C percent for contracting and erecting department; and D percent for any other department there may be which sells goods to customers and to the company. $A\% + B\% + C\% + D\% = 100\%$ factory expense of the business as a whole.

3. All items of general expense must be apportioned to the independent enterprise according to the responsibility of each for the existence of such expense.

4. The total of the *portions* thus found should constitute the total expense for each respective industry.

5. The cost of compressors for delivery to resale agents must be the

same as the cost of compressors for delivery to the company. Likewise for any product similarly handled.

In general, it may be stated that the foundation for determining the economic characteristics of any given business lies in the cost methods used for estimating the expenses incurred by the divisions of the business, by the departments (production and processing) of the business, and their proper apportionment to the products made or the processes conducted, as the case may be.

II. THE ALLOCATION OF THE PRIME COSTS

A. THE ALLOCATION OF LABOR COST

The methods followed to allocate the cost of direct labor vary greatly depending upon the kind of manufacturing activities and the size of the organization.

As a rule, whenever possible, an attempt is made to relate the *earned wages* to the *accounted-for wages*. The earned wages are the total amount of money paid to the direct-labor workers during a given period, generally a week. The accounted-for wages represent the total of labor costs that have been allocated to the products manufactured during the same period. The variance between the earned wages and the accounted-for wages is computed for each production department. If the variance exceeds a certain amount, let us say a few percent, it indicates either that time has been lost in the department—which provides a control of the managerial activities—or that some of the direct labor has not been properly allocated. In either case an analysis of the situation is in order.

If the reverse is true, i.e., if all or almost all of the earned wages have been accounted for, it does *not* necessarily mean that the recorded allocation to each product truly reflects the actual direct-labor expense per product. The extent to which the recorded allocation is accurate depends upon the methods followed in recording it and upon the carefulness with which these methods are being applied. The detailed study of these problems is the subject of cost accounting. In the present section, we will simply discuss in general terms the various approaches which are followed in business and which vary greatly with the conditions of operation.

In a job-order shop, it is customary to issue one ticket for each job, which ticket is actually circulated from department to department throughout the plant as the goods are being manufactured. This

ticket, identified by a serial number, provides a convenient way of recording the time spent on each operation by each worker. Obviously, however, it will happen from time to time that the recording, which is often done by the worker himself and sometimes by a recorder assigned to this duty, will not reflect the actual amount of time spent on the job. Various methods are followed to control the accuracy of this recording. In some shops, time-clock cards are being used, which makes it more difficult to record an inaccurate timing. In other shops, the actual timing is being compared to standards established either on the basis of time and motion studies or on the basis of an average of past experience. If variance from the standard seems excessive, some analysis of the situation is in order.

In job shops that are mostly engaged in non-repetitive work, such standards are not available. This might force management into the use of expensive and sometimes unpleasant systems of control to make sure that the allocation of direct-labor cost reflects accurately the actual facts. To avoid this by providing standards of measurement, an effort has been made in recent years to develop work measurement methods based upon statistical samples. These methods are specifically applicable to the measurement of non-repetitive work.*

In the process industries or in the mass-production industries, the system of allocating direct labor to a specific job cannot be conducted in the same manner as in a job shop. The methods followed vary greatly from case to case. There are, however, some general guiding principles that can be described as follows:

1. An attempt is made to determine a certain cost center. This cost center might be for instance a Fourdrinier machine in a paper mill, or a conveyor in the assembly department of a manufacturing company, or a machine shop.

2. An attempt is then made to allocate the direct-labor cost of operating this center during a given period to the goods processed through the center during the same period.

For instance, if 20 employees work on a conveyor belt during one day, earning direct-labor wages that amount to a total of \$240, and have been able to assemble 1725 units of item No. 1234, this provides

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* See Ralph M. Barnes, *Work Sampling*, 1957. This book includes a report on research on performance sampling conducted by Professor Barnes and his associates. It opens new horizons in the field of work measurement. (See also R. M. Barnes and R. B. Andrews—Performance Sampling in Work Measurement, in *Journal of Industrial Engineering*, December, 1955.)

the figure of $\frac{240}{1725} = \$0.139$ of direct-labor cost per unit of this item.

Whenever the situation is such that a system of cost allocation of this type would require too much control, because too many cost centers would be necessary or because production runs change several times during the day, standard costs are often being used instead of actual cost to allocate the direct-labor expense. These standards are based upon carefully conducted time and motion studies and their reliability is being tested by measuring periodically the variance between the actual direct-labor cost (earned wages) and the standard-labor cost (accounted-for wages). Table XLII illustrates this procedure.

TABLE XLII

WEEKLY DIRECT LABOR REALIZATION
CARRIAGE ASSEMBLY

Department 75 Week No. 12

Cost Center (1)	% Prod. (2)	Std. $ (3)	Act. $ (4)	$ Var. (5)	% Real. (6)
01 Base Assy.	98.2	631	1051	(421)	60
02 Frame B/U	96.0	642	866	(224)	74
03 Circuitry	99.1	1417	2214	(797)	64
04 Harness Inst.	101.3	751	1417	(666)	53
05 Elect. Test	101.0	216	432	(216)	50
06 Gear Box Assy.	87.4	2027	3435	(1408)	59
07 Gear Inst.	84.5	598	729	(131)	82
08 Mech. Test	84.5	321	506	(185)	63
Total This Month to Date	95.7	6603	10,650	(4047)	62
Last Month	94.8				59

Table XLII relates to an actual case, that of the Electronic Manufacturing Division, a division of a large corporation, the management of which has requested that the name of the company be withheld.

The report shown is related to Dept. 75, which is broken down into eight cost centers. Against each cost center is shown in Col. 2 the percent of productivity, which is arrived at by relating the actual production to scheduled production. This serves a purpose of managerial control distinct from the problem we are presently considering. Labor standards are established on all operations. Col. 3 shows a dollar standard conversion of the actual production. Col. 4 shows the actual-labor expense for the same actual production. Col. 5 shows the vari-

ance, in dollars, between standard-labor cost and actual-labor cost, that is, for each cost center, the difference between Cols. 3 and 4. Col. 6 shows the percentage of realization, that is, the ratio of the labor cost at standard (Col. 3) to the actual labor cost (Col. 4).

From the point of view of direct-cost allocation, this report provides:

In column 3: the data required for cost accounting and pricing, which data are based upon certain pre-established standards of work measurement.

In the other columns: the data needed by management to check periodically (in this case week by week) the reliability of the standards they are using.

B. THE ALLOCATION OF MATERIALS COST

Owing to the fact that the price of materials is subject to frequent changes, there is a need for distinguishing between the quantity of materials used, which can be expected to show a certain consistency, and the cost of this quantity, which is subject to sudden and sometimes substantial changes. Just as the allocation of direct-labor costs must be carefully checked, the allocation of direct-materials cost must also be subjected to control. These aspects of the allocation of materials cost will be reviewed.

1. The allocation of the quantity of materials to a given product

The procedures followed vary greatly from case to case. The general principles followed present certain analogies with the principles which govern the allocation of direct-labor cost.

In a job-order shop the same kind of job ticket as the one used for direct-labor recording records the amount of material actually used for production. This should include the wasted materials as well as those that have been transformed into a finished product.

In the process industries or in the mass-production industries there is a fundamental difference between the processes that involve one or few materials and those that involve a great variety of materials. In the former, attempts are being made to record the actual amount of raw material that is being used (this is the case, for instance, in a paper mill or in a plastic molding shop). In the latter, the trend is toward the use of standards. For instance, in a multi-product plant, the recorded quantity of each type of material used for each item manufactured is, as a rule, a standard quantity, based upon engineering studies. The recorded quantity of wasted materials is also, in many cases, a standard quantity.

2. *The pricing of the quantity of allocated materials*

Again, there is a great variety in the practices followed. In the job-order shop, the tendency is to price the materials at their actual price. In larger plants, the materials are sometimes priced in accordance with the methods followed for inventory valuation (Average, LIFO, or FIFO).* As a rule, however, for cost accounting purposes, the practice tends to be to price materials at a standard price. It is advisable to change such standards when the actual price departs substantially from the standards; it is a good policy, however, to avoid changing them during the fiscal year if the variance remains within limits that are considered acceptable from the point of view of cost control.

3. *Control of the allocation of materials cost*

As previously seen, it is advisable to compare the *earned wages* and the *accounted-for wages*, regardless of the method followed in allocating direct-labor cost to each product. The same is true for materials-cost allocation. Again the methods that can be followed vary greatly with the conditions of operation. As a rule the control is based upon a study of the variance between the *cost accounting figures*, which reflect the materials cost as allocated to each product, and the *general accounting figures*, which reflect the variations in materials inventory. The general accounting figures themselves must be checked. This is done by taking from time to time (once or twice a year as a rule) a physical inventory of the raw materials, the finished goods, and the goods in process and comparing this physical inventory with what it should be according to the inventory records (control of quantity) and the books of accounts (control of value). One should always expect a variance due to mistakes in recording, minor pilferage, or unrecorded waste. If the variance is considered to be excessive, some managerial action is in order. If it is within acceptable limits, this indicates that the general accounting figures are reliable for the purpose of controlling the allocation of material costs to each product.

III. THE ALLOCATION OF FACTORY EXPENSE

A. ALLOCATION OF FACTORY EXPENSE TO PRODUCTIVE DEPARTMENTS

Let us now examine the factory expense problem in some detail. In the first place, it will be noted that certain items of factory expense

* See above page 278.

are found directly in the productive departments. These include depreciation and repairs of machinery, foremanship, and some indirect labor and indirect material. In addition, it is not difficult to allocate to each productive department a fair share of the expenses of building depreciation and repairs, of heat, light, and power, and of local taxes and the cost of special services rendered to the department in such matters as special tools. The above items of factory expense may be found for each productive department by direct accounting methods.

In the next place, it will be found that some factory expense to be allocated to the productive departments arises from the operations of the many service departments on which the productive departments depend. The tool crib, the storeroom, the purchasing department, the drafting room, the inspection department, the scheduling and dispatching department, all render needed services to the productive departments. The total expenses of operating each service department are generally ascertainable by direct accounting of wages and salaries, and heat, light, and power apportionment, etc. But how much of each total should be allocated to each productive department is the important matter to decide. This must be done by indirect methods of accounting. In graphic form, the above problem of treating each productive department as a miniature factory, the costs of operating which are to be determined, appears as shown in Figure 59.

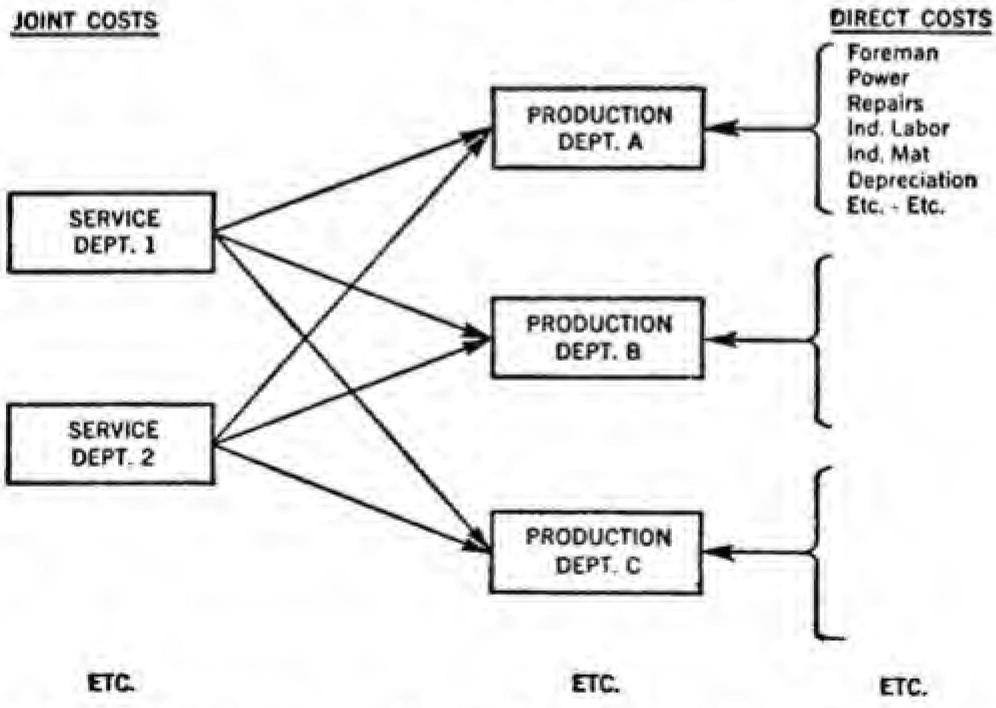

Figure 59. Pattern of Expense Allocation to Production Departments

The total costs of the services used in common are easily determined, but, as the diagram shows, the "values" which are generated in eaoh service department flow to all the production departments, but at different "rates" in each case. These rates are not so easily determined.

In symbolic form, the problem of determining the factory expense for each production department may be written:

$$E = D + (a)1 + (b)2 + (c)3, \text{ etc.}$$

E = Factory expense of production department
D = Factory expense items found by direct accounting
(a) = That proportion of the total expenses of operating service department (1) which is incurred by the Productive Department in question
(b) = Same for service department 2
(c) = Same for service department 3
Etc.

The following example from the writers' experience will illustrate the application of the above procedure.

Example

A certain factory, employing about 250 men and manufacturing several types of metal products of large and small size, found that its prices were out of line with those of its competitors. It therefore wanted an investigation of its processes and costs. While its processes could be improved, its principal difficulty as to pricing was in cost allocation. Its operations were carried on through the following production and service departments. There were five production departments:

1 A machine shop for finishing iron and steel castings, bar stock, etc.
2. A brass machine shop for finishing brass castings which are cast in the company's brass foundry
3. A brass foundry
4. A brass products assembly department
5 An iron products assembly department.

There were the following service departments:

a. A pattern shop for making patterns for the brass foundry and for making patterns for brass castings which are purchased at various foundries in the neighborhood
b. A toolroom for the making and repairing, as well as for the care and distribution, of tools for the iron shop, brass shop, foundry, and assembly departments
c. A power plant
d. A repair and maintenance gang for the upkeep of all machines and repair of buildings for all productive and service departments

e. An engineering department for designing all products manufactured and occasionally designing equipment and fixtures for some of the service departments

f. A storeroom for the custody of all raw materials

g. A stockroom for the custody of all finished products

h. A shipping department

i. A yard gang for general service

j. A general factory office for planning, supervision, and record keeping.

The problem was to determine, with a reasonable degree of approximation, the total amount of factory expense to be apportioned to each productive department in order that this expense might in turn be assessed against the products made in these departments.* To this end, it is convenient to set the problem in the tabular form shown in Table XLIII.

TABLE XLIII

ALLOCATION OF FACTORY EXPENSE TO PRODUCTIVE DEPARTMENTS

Items of Factory Expense (*Monthly*)		Productive Departments				
Direct	Total	No. 1	No. 2	No. 3	No. 4	No. 5
1. Taxes	420	100	80	20	160	60
2. Insurance	710	200	110	80	90	230
3. Indirect labor	5,000	1,000	800	1,200	1,500	500
4. Indirect materials	5,000	800	500	1,700	1,000	1,000
5. Supervision	2,500	500	900	600	300	200
6. Depreciation	1,700	400	300	200	600	200
		Service Departments				
a. Pattern shop	1,500	500	500	500	...	...
b. Toolroom	3,000	300	1,000	700	1,000	...
c. Heat, light, power	2,500	800	700	200	200	600
d. Maintenance and repair	1,600	300	200	500	400	200
e. Engineering and design	2,000	1,000	500	500	...	...
f. Rough stores	2,500	600	800	300	500	300
g. Finished stockroom	1,000	100	200	600	100	...
h. Shipping	1,300	700	600	...	...	...
i. Yard gang	4,000	800	600	1,000	1,200	400
j. Factory office	2,500	600	900	200	300	500
TOTAL	$37,230	8,700	8,690	8,300	7,350	4,190

The cost of operating each service department must be determined by an analysis of the items of expense which it incurs. The pattern shop may be taken as a typical example, for which the items of expense were:

* For the allocation of factory expense to the products, see page 304.

1. Materials (direct and indirect)
2. Heat, light, and power
3. Insurance
4. Taxes
5. Labor, direct and indirect
6. Maintenance and repairs
7. Depreciation, etc.

The probable magnitude of each of these items for any accounting period, say for one month, may be found as follows:

1. Materials—estimated from past records
2. Heat, light, and power—from inspection and test, as a result of which it may be found that six percent, for example, of the entire cost of this item for the whole factory for the month is probably caused by the operation of the pattern shop
3. Insurance—from wages of employees for compensation insurance; from proportion of value of machinery and inventory to value of machinery and inventory of the whole plant for fire insurance; from area occupied to entire area of all departments for fire insurance on building
4. Taxes—from proportionate value of building and equipment of pattern shop and the whole plant
5. Supervision—from past records and inspection
6. Depreciation—from rates appropriate to each type of equipment.

The apportionment of the totals of the above items (direct and service department charges) to the productive departments may be made as follows: All the direct charges, with the exception of supervision, are determined separately for each department as indicated above. Supervision may be apportioned with reasonable accuracy on the basis of the number of direct labor employees engaged in each productive department to the total of such employees for all productive departments. The pattern shop may be assigned as an item of factory expense to the brass foundry and to the iron machine shop in proportion to the average wages paid for work on patterns for the iron foundry and for the brass foundry, as shown by the records of past performance. Thus, if two-thirds of the wages paid are for patterns for iron castings, then the estimated total cost of operating the pattern shop will be apportioned two-thirds to the iron machine shop and one-third to the brass foundry. The total cost of operating the toolroom will be apportioned to the iron machine shop—and the brass machine shop on the same basis. The other productive departments will use the toolroom so little in comparison to the machine shops that it is within the degree of approximation to neglect them in this apportionment. However, if this should for any reason not be the case, then naturally that department which may require toolroom service to any considerable extent must be included in the apportionment.

Heat, light, and power must be apportioned to the productive department by test and inspection.

Maintenance and repairs cost for each productive department are estimated from past records.

Engineering and design are so broadly used by each productive depart-

ment that it is not readily seen how they may be rationally apportioned to the several productive departments. In all probability, the apportionment will usually be approximately right if made on the basis of the ratio of the productive hours or direct-labor wage in each productive department to the total of productive hours or direct-labor wage of all productive departments.

Rough stores may be apportioned to the iron machine shop, brass machine shop, and brass foundry on the basis of the floor space occupied and the proportionate amount of labor employed in handling the stores of each of these departments. If purchased parts for use only in the assembly departments are also handled as a part of the rough storeroom and if also finished parts are withdrawn from this storeroom for the assembly departments, then these departments must also participate in the expense of maintaining the storeroom, and the participation may likewise be made on the same basis. It is not always apparent how the cost of maintaining the finished stockroom may be apportioned to the productive departments. In all probability, this had best be apportioned to the iron machine shop and the brass machine shop on the basis of the relative amount of expense in preparing and handling each class of shipments (iron products and brass products) and assigned to the iron machine and brass machine shop accordingly.

The cost of operating the yard gang in relation to the operation of the productive departments is not always apparent. Perhaps the best method of apportionment is by inspection of the work the yard gang does and estimating the probable responsibility of each productive department for necessitating this work.

All of the office expense may be apportioned to the productive departments on the basis of the relative average monthly productive hours anticipated for each productive department. It is true that some of the office expenses are incurred by the service departments and logically should be apportioned to the service departments. But it was found in this case that the result was about the same as if the apportionment were made direct to the productive departments, and hence the simpler procedure was adopted.

Principles

The above type of procedure for determining the probable factory expense which will be incurred and should be allocated to each productive department is, in summary:

1. Classify the accounts or expenses in such manner that each type of expense may be summarized for each department of the business.
2. Assemble the expenses for the past year as incurred by each department, both productive and service. These may be averaged on a monthly basis if no change in operations is anticipated for the coming year. If a change is anticipated, such as, for example, an addition to the machine shop or installation of new furnaces in the foundry, then the expenses anticipated in such changes should be included in the estimates.

3. Apportion the expenses of each service department to the productive department according to the probable use which each productive department will make of each service department. The anticipated expenses directly incurred plus those apportioned from the service departments constitute the anticipated total factory expenses of the productive department.

Accordingly, the probable total factory expenses to be allocated to each productive department is found. It now remains to find some rational method by which each total may be assessed to the products flowing through each productive department.

B. ALLOCATION OF FACTORY EXPENSE TO THE PRODUCTS

The objective in this procedure is twofold: first, to assess to each operation, each part and each product its equitable share of the factory expense; second, to provide that the total factory expenses assessed will closely approximate the factory expenses incurred. Accordingly, the important question is: What is an equitable basis for assessing each operation, each part, and each product with its share of the anticipated factory expenses? Various methods are used, depending on the nature of the operations performed. The general principles of these methods will now be considered and illustrated by examples.

In the mechanical or metal-working industry, there are three general methods used for the allocation or distribution of factory expense to processes, to parts, and to products, and these are on the basis of materials, wages, or man-hours. In the process industries, the factory expense is often distributed on the basis of either the quantity or the value of material output. Some process divisions, such as foundries, associated with the metal working industries use this method.

1. *Factory Expense Distribution by Materials*

EXAMPLE

a. MATERIALS (VALUE)

A certain manufacturer finds that the following total costs of manufacture have been incurred on account of the products sold during the month:

Material	\$20,000
Labor	10,000
Factory expense	10,000

It is observed that, for every dollar spent for materials, \$0.50 was spent for factory expense. Accordingly, therefore, he estimates that any given

part, let us say product A, incurring a unit materials cost of \$3.00 and a unit labor cost of \$2.00, has incurred a unit factory expense of \$1.50, and that the unit manufacturing cost is therefore \$6.50. Product B, on the other hand, required \$1.00 worth of material and a unit labor cost of \$2.00, and it is assumed to have incurred a unit factory expense of \$0.50; the unit cost of manufacture is estimated to be \$3.50. If this method of estimating is applied to all the products sold, it appears that the total factory expense will be accounted for; that is, the sum of all unit factory expense items assessed to each product will balance with the total factory expense.

b. MATERIALS (WEIGHT)

If, in addition to the value of the material, a record of weights or quantities is compiled, factory expense distribution by weight in quantity is possible. If a plant for any given month incurs a factory expense of \$8,000 and there are 25,000 barrels produced, then the factory expense per barrel will be found to be \$8,000 ÷ 25,000 = 32¢. In such factories, however, it may be found desirable to determine the apportionment of factory expense by processes in order to compare the economy of operations of each processing department from month to month.

In foundries producing a uniform style and weight of casting, the factory expense may be apportioned to the production for the month on the basis of the poundage produced. If, for example, the factory expense for the month for a brass foundry is \$20,000, and 400,000 pounds are produced, the factory expense per pound is 5¢. A casting weighing 3 pounds would accordingly be apportioned a factory expense of 3 x 5¢ or 15¢. When, however, the foundry produces a wide range of castings, some of which may be very heavy and require intricate core work while others are comparatively light and require no core work, obviously each class of castings is not equally responsible for the factory expense incurred, and, therefore, a subdivision of factory expense must be made, applicable to each class of castings. That is, each class of castings will bear a predetermined proportion of the factory expense. Suppose, for example, there are found to be three classes of castings, to be designated as Class A, Class B, and Class C. A careful study of the operations attending the production of each class in the matter of factory expense involved may indicate that Class A occasions 50 percent of the factory expense; Class B, 30 percent; and Class C, 20 percent, when the ratio of poundage of each class produced to the total output is a given amount or lies between certain limits. Accordingly, if the total factory expense is \$20,000 for a given month, all castings of Class A produced in that month should be burdened with 50 percent of \$20,000, or \$10,000, while all castings of Class B should be burdened with 30 percent of \$20,000, or \$6,000, etc. It is important to note, however, that, should the ratio of poundage of each class to the output be materially changed, then the percentages of factory expense to be applied to each class should also be changed. If the entire foundry is used to produce Class A castings alone, it is obvious that 100 percent of the factory expense should be incurred by Class A products.

PRINCIPLES

It may be stated in conclusion, regarding the apportionment of factory expense by the percentage on materials methods:

1. That it is applicable to the factories producing bulk materials, such as sugar, soap, cement, castings, forgings, paper, pulp, paint, bread, yeast, and the like.

2. That when the final products, although the processes are common to all products up to a certain point, are of different styles or types, as in the foundry referred to above, the factory expense should be apportioned to the several styles or types of products after a careful analysis of the extent to which each is responsible for the factory expense incurred.

3. That the apportionment of factory expense as just indicated, since it is necessarily founded upon a given ratio of poundage of each style or type to the output of the plant as a whole, is no longer a correct apportionment when the ratios are changed to a considerable extent, and a reapportionment must be made, therefore, in order that a more accurate cost may be determined.

4. That in plants of the above type, it is useful to determine the proportion of the factory expense to be borne by each process or each group of related processes, and, therefore, the total factory expense should be apportioned according to processes or groups of processes on the basis of the responsibility of each in the incurring of the factory expense.

5. That the apportionment just indicated may be made by careful determination of the amount of power, heat and light, insurance, taxes, indirect material, indirect labor, and other items of factory expense entering into each process or group of processes, and applied to the cost of the product on the basis of the poundage produced in the time during which the expenses were incurred.

6. That since some of the factory expense items (and sometimes a large proportion) are constant for the month, the factory expense per pound of product produced will vary in accordance with monthly production.

2. *Factory Expense Distribution by Wages*

EXAMPLE

Another, observing this same statement of total costs as given above for the example of factory expense distribution by value of materials, notes

that, for every dollar paid to direct labor, a factory expense of \$1.00 is incurred. Accordingly, he would estimate the unit cost of manufacture of Product A as unit materials cost \$3.00, unit labor cost \$2.00, and unit factory expense \$2.00, giving a unit cost of manufacture of \$7.00. Product B would be estimated to have a unit materials cost of \$1.00, a unit labor cost of \$2.00, a unit factory expense of \$2.00, and a unit cost of manufacture of \$5.00.

Now which is the more nearly correct? Each method accounts for the total factory expense for the month, just as we find that $2 + 3 + 5 = 10$, and $1 + 2 + 7 = 10$. But, if the first manufacturer sells each unit of Product A for \$9.00, he believes that he has made a unit gross profit of \$2.50, whereas the second manufacturer selling each unit of Product A at \$9.00 believes that he has made a unit gross profit of \$2.00. Which is correct? Maybe both are wrong.

This method of factory expense distribution is based on the theory that each article made incurs a factory expense in direct proportion to the direct labor wage paid in its production. This theory therefore assumes that each item of factory expense is a function of direct labor wages, and, therefore, that the items, for example, of indirect labor—of toolroom service, power and indirect materials, to mention a few—are functions of direct labor wages. Accordingly, let it be assumed that a given plant has in it a group of machines using special tools which must be fitted to the machines for each job, as well as having a group of benches at which skilled mechanics are at work at hand processes. The machine laborers require power for operating the machines, toolroom service for making, repairing, and setting up special tools, laborers to bring casting and take finished parts away, men to repair belts and oil the machinery, men to sweep away the chips. The machinist at the bench requires no such service. He is working with equipment which has little depreciation and makes no demand for power. Is it reasonable to assume that an hour's work at the machines at one dollar per hour will incur a factory expense of only two-thirds of that incurred by an hour's work by a machinist at the bench who is receiving \$1.50 per hour? Yet that is the basis on which the apportionment would be made by this method. Clearly, therefore, if such conditions obtain in a factory, the percentage on wages method of factory expense distribution is not equitable.

The writers encountered this method of factory expense distribution in a factory manufacturing metal furniture, metal shelving, vault fixtures, bank fixtures, and similar equipment. It served quite well for the apportionment of the factory expense as a whole; that is, there was little over- or under-absorbed expense month by month. It happened, however, that all products did not equally engage the attention of all departments of production. In fact, some products never passed through departments employing very expensive machinery requiring considerable power while other products were largely made at the bench. It was quite evident that the ratio of factory expense to direct labor wages was not the same for all departments. After investigation, it was found that some departments had a ratio as high as 225 percent, while in other departments (bench work) the ratio was only 35 percent. The factory as a whole had a ratio of 100 percent. Quite obviously the result of applying the 100 percent ratio to each department was

that the cost of some products was estimated too low, and bids based upon these estimates resulted in securing orders on which no profit was being made, while other products were estimated at too high cost and business was not as readily secured in competition with other manufacturers quoting lower prices. Now the plant as a whole was earning a profit, but it was found that, upon reapportionment of factory expense and consequent revision of price lists, the business expanded along safer lines, and larger profits were earned. The fact that one line of products may bring a profit of $100,000 while another line may lose $20,000 is not always apparent when the mind is focused on a net profit of $80,000, especially if that is a fairly good profit on the amount of goods sold.

PRINCIPLES

The conditions under which the percentage on wages method may be fairly applied in the determination of factory costs are:

1. When the skill of the workers and their rates of pay are uniform and the type of equipment they use is fairly similar, and they are all working on the same general class of work.

2. When the factory is divided, for purposes of cost finding, into productive divisions and each division has a proportionate factory expense applied to it in accordance with the extent to which each is responsible for the factory expense, and each division is uniform in equipment, and workers on each product engage the attention of all groups of machines in that division.

If the conditions are as given under (2), it may be found that there are three principal divisions to be known as Department A, Department B, and Department C, and the percentage on wages applicable to each may be 100, 50, and 125, respectively. A given article may be made in Departments A and C at direct-labor costs of $4.00 and $3.00, respectively. The factory expense to be charged will accordingly be $\$4.00 \cdot 100\% + \$3.00 \cdot 125\% = \$7.75$. Another article may be made in Departments A, B, and C, at direct-labor costs of $2.00, $5.00, and $1.00, respectively. The factory expense on this article would be $\$2.00 \cdot 100\% + \$5.00 \cdot 50\% + \$1.00 \cdot 125\% = \$5.75$.

3. Factory Expense Distribution by Direct-Labor-Hours or Man-Hours

EXAMPLE

Upon further examination of the accounts, in the case of the first example, it is found that there were 15,000 direct-labor-hours employed on all the products sold during the month. Accordingly, it may be assumed that on

the average for every hour of direct labor accounted for during the month there was incurred a factory expense of 66 2/3¢. While labor received an average of 66 2/3¢ per hour, the rates varied from 40¢ to 90¢ per hour. Let it be assumed that each unit of Product A required 4 hours of direct labor at 50¢ per hour of wage. Then, accordingly, the average cost of manufacture of each unit of Product A would be estimated to be: material, \$3.00; labor, \$2.00, as before; and factory expense of 4 · 66 2/3¢ = \$2.66 2/3, totaling \$7.66 2/3. If each unit of Product B requires 4 hours of direct labor at 50¢ per hour, then the factory cost of Product B is estimated to be: material, \$1.00; labor, \$2.00; factory expense, \$2.66 2/3; giving a unit cost of manufacture of \$5.66 2/3.

4. *Comparison of the Three Methods*

Thus, we find so far three different assumptions by which factory expense may be assessed to the cost of manufacturing the same product, and each assumption leads to a different answer as to what is the unit cost of manufacture of a given article. Each method gives a perfectly satisfactory accounting for the total factory expenses as far as an authentic balance of accounts is concerned. Apparently the problem is more than one of arithmetic.

In general, the man-hour method of expense distribution may be considered more rational than the percentage on wages method, because it is based on the principal factor of factory expense, which is time. However, it must be used with the same discretion and common sense as was indicated for the other methods of expense distribution presented above. Obviously, if the productive departments of a factory vary widely in the nature of equipment and skill of operators, no average expense per productive hour will be indicative of the real factory expense of any department, and, therefore, not useful in cost determination.

EXAMPLE

The direct-labor-hours per month of the factory for which the analysis of factory expense is given on Table XLIII, page 301, were as follows:

Direct-labor-hours	Productive Department				
Total	1	2	3	4	5
30,000	10,000	8,000	6,000	3,000	3,000

Accordingly, therefore, the factory expense is to be apportioned to each product in accordance with the direct-labor-hours spent on it by each department at the following rates:

$$\text{Department 1} \quad \frac{8,700}{10,000} = 87¢ \text{ per hour}$$

$$\text{Department 2} \quad \frac{8{,}690}{8{,}000} = 108.6¢ \text{ per hour}$$

$$\text{Department 3} \quad \frac{8{,}300}{6{,}000} = 138.33¢ \text{ per hour}$$

$$\text{Department 4} \quad \frac{7{,}350}{3{,}000} = 245¢ \text{ per hour}$$

$$\text{Department 5} \quad \frac{4{,}190}{3{,}000} = 139.66¢ \text{ per hour}$$

The average hourly rate will be $\frac{37{,}230}{30{,}000} = 124.1¢$ per hour.

Suppose, for example, that a product had been manufactured exclusively in Department 1, and that 10 direct-labor-hours had been spent thereon. If an apportionment of factory expense by departments is made, the product will be charged with a factory expense of \$8.70. If, however, the total factory expense is used and all products are assessed at the average hourly rate, then this particular product would be charged with \$12.41 factory expense. A product priced on this basis may not be sold in competition with other manufacturers who have a better knowledge of costs. If, on the other hand, a product is made exclusively in Department 4 and consumes 10 direct-labor-hours, it should be charged with a factory expense of \$24.50; but if the average rate for the entire plant is used, the factory expense incurred would be estimated at \$12.41. Pricing on this basis may result in business being secured, but it would not be profitable.

IV. THE ALLOCATION OF SELLING AND ADMINISTRATIVE EXPENSE—ITS LIMITATIONS

1. GENERAL CONSIDERATIONS

In those industries in which the products made are sold by weight or by some standard unit, for example, pulp mills, sugar mills, brick plants, lumber mills, to mention a few, the total of all expenses, including selling and administrative expenses, can be divided by the total units of products produced, such as the ton, the barrel, the 1,000 board feet, etc., and the total cost of the unit of product obtained. By this means the net profit per pound may be determined. But when a company produces a variety of products or a number of sizes and styles of the same type of product, such as table model radios and cabinet model radios with phonograph, the allocation of selling expense and administrative expense to specific products is not permissible by the same rational means as are possible in the allocation of

the factory expense. Yet if the profit from the sale of each product is to be found, or more especially if the businessman is to be assured that some products are not being sold at a loss, some basis for the allocation of selling expense and administrative expense must be found. This is particularly necessary in those cases in which some products require much more sales promotion than others or some departments of the business concerned with one or more products demand a disproportionate amount of attention from some of the administrative officers. These conditions are usually found where a new line of products is being promoted by a company and the overhead expenses in development and sales promotion are disproportionate to the sales income of the new product for perhaps several years. It would not be equitable to average the overhead of the entire plant so that the older and better established products are made to carry any of the added overhead. The only rational basis for allocation of selling and administrative expenses in situations as above described is to make a study of the time and expenses of sales and administrative executives in relation to the different products dealt with and from this study to set up an approximate proportion to be allocated to each group of products. Unless such a procedure is followed, it may readily happen that the pricing of some products may be out of line with competitive offerings or be so priced as to result in the products being handled at a loss. Accounting techniques for handling such problems are not well developed, since manufacturers generally price their products on the basis of manufacturing cost and attempt to keep the total of selling and administrative expenses well within the gross profit margin so as to realize a satisfactory profit for the business as a whole.

Many large companies, however, do set up separate sales and administrative divisions for each of the varieties of products they handle, with the result that the major portions of selling and administrative expenses can be properly allocated. But the smaller- and medium-sized businesses generally do not departmentalize their overhead activities, and consequently the final or ultimate cost of their products as delivered to the customer may be determined with a high probable error in some cases.

2. CONTROL OF DISTRIBUTION COST ON A GEOGRAPHICAL BASIS

In many instances it will be possible to individualize the selling costs on a geographical basis. This offers the advantage of defining clearly the responsibility of the executive in charge of a given selling

district. At the same time, it provides a yardstick of comparison. By comparing the selling expense in one district to the expense in another district or, rather, to the average of the other districts, it is possible to measure, within reasonable limits of approximation, sales executives' efficiency. Of course, such expenses have to be prorated (by dollar of sales, by size of the market, etc.) and some adjustments (for regional variations in disposable income or in the cost of living, for instance), have to be made. The necessity of making some empiric adjustments obviously reduces the degree of accuracy and therefore the reliability of the comparisons made. However, useful estimates of the *relative* efficiencies of sales executives can and should be made.*

3. CONTROL OF DISTRIBUTION COST ON THE BASIS OF THE SIZE OF ORDERS

One of the latest developments in the control of distribution costs is the control on the basis of the size of orders. Except for the conventional classification of wholesale and retail orders, little attention has for a long time been paid to the cost of delivering comparatively small orders. The constant increase in distribution costs is probably the reason for the extensive studies now being made in the field, notably by the United States Department of Commerce.†

For instance, a detailed analysis of costs showed one company that 42 percent of its accounts, consisting of only 10 percent of the sales volume, were unprofitable. These customers were dropped gradually, whereby marketing expenses were cut from 22.8 percent of sales to 11.5 percent. A 2.9 percent net *loss* on sales was changed to a net *profit* of 15 percent.

4. CONCLUSION

The principal limitations in the allocation of selling expenses come from the lack of detailed data.

The technique of cost accounting has been extensively developed during the last few decades, facilitating a precise analysis of production costs, thereby opening the way for reducing them substantially.

However, the accounting of selling expense did not develop as far as that of production expense. As there is no refined expense allocation directly providing detailed data, empirical studies of costs on a sta-

* See Chapter VII, page 186, for an example of an analysis of cost on a geographical basis.
† "How Manufacturers Reduce Their Distribution Costs," Economic Series No. 72, Washington 25, D.C., 1948.

tistical basis have been made by Professor Joel Dean of Columbia University, who pioneered the field.* Such studies have thrown light on an important and, up to then, too little known matter. They have stimulated extensive research work in the field.†

* Joel Dean, "Statistical Determination of Cost," 1936. "The Relation of Cost to Output for a Leather Belt Shop," 1941. "Statistical Cost Functions for a Hosiery Mill," 1941. "The Long-Run Behavior of Cost in a Chain of Shoe Stores," Chicago, 1942. Etc.

† See among others: B. J. Heckert and R. B. Miner, *Distribution Costs*, Ronald Press, 1953, and Frederick M. Eisner, *Profit Analysis. How to Allocate Distribution Costs*, 1953.

XII

COSTS PER UNIT OF OUTPUT

THE SUBJECT MATTER of Part I dealt principally with the economic characteristics of industrial production as applied to a factory and a business as a whole. The preceding two chapters of Part II dealt with some more detailed aspects of the problems of the classification and allocation of the several factors of costs within the factory and the business as a whole. It is our purpose now to consider the problems associated with the determination of the costs of operating a process, and of performing a unit operation, and the relation of such costs to the rate of production. This problem assumes importance when alternate equipments and methods of manufacture are under review. Since a process may be operated or a unit operation may be performed by a number of different methods or by the use of several types of equipment, each one of which is acceptable *functionally*, that is, each one can do the work satisfactorily so far as quality of performance is required, it becomes necessary for purposes of economy to select among the several func-

tionally capable machines and processes that one which will perform the work at minimum cost. But since cost is related to the rate of production, the analysis of the relative costs of unit operations must also take into consideration the quantities to be produced within a given time period. In this chapter consideration will be given to the analysis of costs per unit of output at varying rates of production. The chapter following this one will be devoted to some applications of the analysis to the determination of comparative costs.

I. TYPES OF UNIT COSTS

The term "unit cost" is applied to a number of kinds of units, and therefore it must be amplified to give it specific meaning. The types of unit costs which are of use for control purposes are the following:

a. The *specific* cost of a process or unit of operation and of the units of output resulting therefrom.

b. The *average* cost of *identical* piece parts, such as frames, gears, shafts, etc.

c. The *average* cost of the units of a class of *identical* commercial products such as radios, desks, drills, cloth, etc.

In addition, such unit costs as the expense incurred per dollar of income of the business as a whole or of any division thereof are frequently found helpful in visualizing the economic characteristics of business operations. We will now proceed to investigate the method by which the types of unit costs listed above may be determined, *particularly as they are affected by the rate of production.*

II. AVERAGE COSTS OF IDENTICAL COMMERCIAL UNITS OF PRODUCT

A simple example of identical commercial units of product is a given weight of sugar—the pound. How much does it cost to produce a pound of sugar when the mill is operated at full capacity or 75 percent capacity or half-capacity? The beet sugar mill reported on in Chapter VI was found to have a total expense trend in relation to tons of beets sliced, determined as follows: *

The constant total expenses per annum of the company are estimated to be $1,220,000. The variable total expenses per annum of the company, for capacity operations of 200,000 tons of beets sliced per season,

* See Chapter VI, pages 164*ff*.

are estimated to be $1,500,250. The constant unit cost per ton of beets, arising from the variable total expenses is:

$$\frac{\$1{,}500{,}250}{200{,}000} = \$7.50 \text{ per ton}$$

With a yield of 232 pounds of sugar per ton of beets sliced, the constant unit cost per pound of sugar arising from the variable total expenses is:

$$\frac{750}{232} = 3.234¢ \text{ per pound}$$

The constant total expenses of $1,220,000 give rise to a variable unit cost per pound of sugar of

$$\frac{\$1{,}220{,}000}{232 \cdot T} = \$5{,}258.6 \cdot \frac{1}{T}$$

where T = number of tons sliced per season.

From the above observations, the table of cost per pound of sugar at varying rates of production is prepared (Table XLIV).

TABLE XLIV

TOTAL COST PER POUND

Annual Slice 1,000 Tons	Constant Unit Cost	Variable Unit Cost	Total Cost
40	3.23¢	13.03	16.26
60	3.23¢	8.69	11.92
80	3.23¢	6.52	9.75
100	3.23¢	5.21	8.44
120	3.23¢	4.35	7.58
140	3.23¢	3.72	6.95
160	3 23¢	3.26	6.49
180	3.23¢	2.82	6.05
200	3.23¢	2.60	5.83

These items of cost when plotted as in Figure 60 show how each unit cost and the total cost per pound vary with the rate of annual production. If the revenue from the sale of pulp and molasses ($325,600) is credited to operations, the total cost per pound will be reduced for all rates of production by

$$\frac{\$325{,}600}{232 \cdot 200{,}000} = 0.7¢ \text{ per pound}$$

In the above example, there is found a unit of output which is uniform; that is, a pound of sugar is a pound of sugar. If now a similar analysis is made of the cost per ton of steel, for example, as produced by the United Steel Corporation, the average cost so obtained would be the average for rails, sheets, bars, tool steel, and other shapes and qualities. For the 10-year period just prior to World War II, the United Steel Corporation produced steel at an average cost of \$182,100,000 + \$55.73 per ton. When it produced 14 million tons, as it did in 1928, the average cost was

$$\frac{\$182,100,000}{14,000,000} + \$55.73 = \$68.73 \text{ per ton}$$

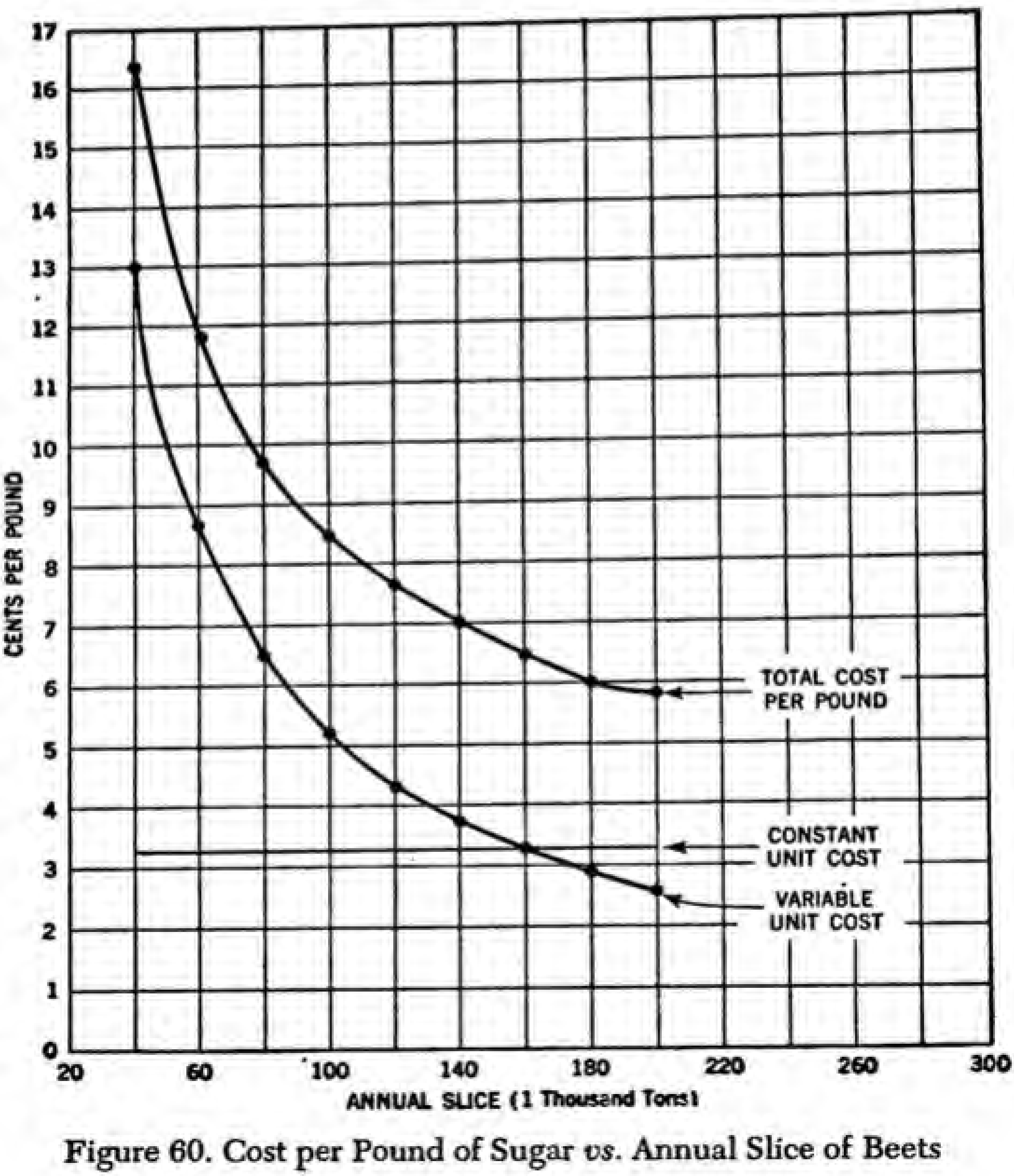

Figure 60. Cost per Pound of Sugar *vs.* Annual Slice of Beets

In 1938, when it produced 7.8 million tons, the average cost was

$$\frac{\$182,100,000}{7,800,000} + \$55.73 = \$79.07 \text{ per ton}$$

But the different qualities of steel produced were processed by different methods and, accordingly, their costs varied quite widely from the average. In this case, the average costs cannot be used as a basis for pricing the different qualities and shapes. Each quality and shape of steel must be analyzed for cost, if effective control of such costs is to be obtained.

In order to ascertain the cost of a product at varying rates of production, particularly a product which is one of several being manufactured in the same plant, but each of which is operated on by different machines, or a product which is assembled from a great number of piece parts, the cost of each unit operation, and of each part as these are operated and produced at varying rates of production, must be found.

III. DEFINITIONS

Unit Operations. The connecting rod of an automobile engine, as manufactured by one company, is machined at 16 stations or work places. The operations performed in sequence are:

1. Grind flash from wrist-pin end
2. Straighten and check location of bosses with face
3. Drill wrist-pin hole
4. Chamfer both sides of rod
5. Broach wrist-pin hole
6. Broach sides of bolt bosses and bolt head seat
7. Drill 3/16″ anchor hole in rods
8. Broach joint face and crank; bore diameter of rod
9. Drill and ream bolt holes
10. Repair bolt holes where necessary
11. Countersink bolt holes opposite joint face in rods
12. Drill 3/16″ angle oil hole, 1/8″ deep and 1/16″ hole through
13. Repair anchor holes and oil holes
14. Burr oil holes
15. Grind joint faces of rod and cap
16. Wash (hot) before assembly.

Each one of these is a unit operation and is performed by a different workman, using particular machines or tools which are adapted to

the job to be done. Each unit operation must be supported by a number of services of maintenance and supply. Each unit operation is conducted at different costs per hour and occasions different costs per piece.

The costs of performing a unit operation arise from three sources:

1. Those due to the possession of the machine
2. Those due to the supporting services
3. Those due to operating the machine.

Each of these sources of cost may be formulated as follows:

The Cost to Possess

The machine or equipment used to perform a unit operation represents an investment. As such it incurs taxes, and it should also be covered by insurance. During the life of the machine, arrangements must also be made for charging an increment of its investment to the cost of the product in order to provide for capital recovery. This is done by the depreciation charge. If, for example, a particular machine represents an investment of $10,000, and it is determined that this capital is to be recovered in 5 years, the annual depreciation charge to the products made by its use will be 20 percent of the investment or $2,000. If the machine is expected to be operated 2,000 hours in the year, then the hourly depreciation charge is $1.00. The tax assessor of the local community in which the factory is located does not assess a tax on each individual machine of the factory but he does assign an assessed value for taxing purposes on the factory as a whole. This assessed value times tne tax rate becomes the annual tax which the owners of the business must pay to the community. To reflect this expense in the cost of production, and also that each productive asset may carry its share of the tax burden, it is necessary for the accountants of the business to allocate the taxes to each production division of the factory, and from thence to each unit of production. For purposes of estimating the probable increment of the tax burden to be borne by the production machine the tax rate is applied to the investment in the machine. If the tax rate is 3 percent, the annual tax burden is $300, and for 2,000 hours of operation per year the hourly tax burden is 15¢. The same procedure is applicable to the determination of the insurance burden to be assessed to the machine. If the insurance rate is 2 percent, the annual insurance charge in the above case is $200 and the hourly charge is 10¢.

Accordingly, let

I = the investment in the machine, in dollars
p = the sum of the percentages for annual taxes and insurance and for capital recovery through depreciation

and

N = the estimated number of hours the machine is to be in operation during the year.

Then the hourly cost to possess is

$$\frac{I \cdot p}{N}$$

In the above example, if the machine is estimated to be in operation for 2,000 hours in the year, then

$$\frac{I \cdot p}{N} = \frac{\$10{,}000(20 + 3 + 2)\%}{2{,}000}$$
$$= \$1.25$$

The Cost of Services

Every productive machine must carry its share of the departmental overhead, which is itself a portion of the total factory expense. The assignment of a portion of the total factory expense to each department is made in accordance with cost accounting procedures, which vary greatly from one company to another. What the share of each productive machine is to be, in addition to the cost to possess determined as indicated above, is usually estimated by applying an average hourly rate. For example, if the annual departmental overhead (not including the specific items accounted for in the cost to possess) is \$20,000 per year and there are 20 productive machines in the department which are about alike, then an approximate estimate of the annual cost of service of each machine is \$1,000. If the department is operated for 2,000 hours in the year, then the service burden on each machine will be 50¢ per hour. Let the annual service charge be designated by the letter S. Then the hourly service charge is $\frac{S}{N}$.

The Hourly Burden

The cost to possess plus the cost of service expressed in terms of hourly costs constitutes the hourly burden on the machine. In the

above example, this is \$1.25 + 0.50 = \$1.75. In symbols, the hourly burden is

$$B = \frac{I \cdot p + S}{N}$$

The Cost to Operate

This item of cost refers to the wages paid to the workman who operates the machine. If the machine must be set up by a skilled mechanic who receives a higher rate of pay than the machine operator, the wages of the set-up man are usually included in the service burden. If the operator of the machine requires a helper in constant attendance, as is the case with certain large machines in which large and cumbersome sheets are cut, punched, or bent, then the cost to operate consists of the wages of the operator plus the wages of the helper. The hourly labor cost of operating a machine may be expressed by the letter L.

In summary, then, the hourly cost to possess, service, and operate a productive machine is

$$\frac{I \cdot p + S}{N} + L = B + L$$

IV. THE NATURE OF THE COST ITEMS

In order to associate these cost items with the products made, that is, to find the cost per piece, it is necessary to examine the nature of each cost item.

The annual cost to possess, as the term implies, arises solely from the possession of the machine, and is not affected by its operation. If the machine is idle, the *annual* charge is the same as when the machine is operating and producing. But the hourly cost to possess is based on the annual cost to possess and the estimated hours of annual operation. If the machine is estimated to operate full shop time, say 2,000 hours per year, or to be in operation only 1,000 hours and idle 1,000 hours, the hourly cost to possess to be charged to the products made will be twice as much in the latter circumstance as in the former.

The annual cost of servicing the machine consists of two classes, the standard charges and the specific charges. The standard charges of factory expense are such as: cost of maintaining a superintendent, a foreman, storeroom service, materials handling service, accounting service, light, heat, etc. These may be termed stand-by services because they must be maintained for the department as a whole, ready

to render service as needed. These services are rendered to the machine when it is in operation but they must be maintained ready for service even though the particular machine under consideration is temporarily idle.

The specific service charges are those which are incurred when the machine is producing. If the machine is a heating furnace, the specific charges are fuel and relining costs. If it is a lathe, the specific charges are for power to operate and for cutting tools and repairs.

As a rule it is found impractical in most factories to separate these two charges in the accounting for factory expense, and hence they are grouped together as one charge. Since the stand-by charge is usually the dominant one of the two, the annual cost of servicing is treated as a constant cost to be charged to the machine on an hourly basis, whether or not the machine is in operation. For example, if a given department of manufacture has an annual factory expense, not including the cost to possess items, of $20,000 and there are 20 machines in the department, each machine carries an annual burden of $1,000, which must be recovered in the sale of the products which each machine turns out. If the estimated hours of annual operation of the machine are 2,000, the hourly service charge is half what it is if the machine is estimated to operate only 1,000 hours per year.

Cost accounting practices vary over a wide range and the reader should therefore not be surprised to find that the hourly burden on a machine, due to both the cost to possess and the cost of services, is estimated quite differently in many factories. In fact, the writers have observed some very large and reputable companies using such crude and empiric methods for determining machine burdens, that as a result they have been grossly misled as to the costs incurred per unit of output. This has affected seriously the pricing of the product as well as given a false perspective in judging the relative economies of alternate methods of production.

The *cost to operate* is a cost incurred by the wages paid to the operator of the machine plus the wages of the helper, if he has one. It is conveniently computed on an hourly basis. A machine does not need to be turning over to be in operation. If a workman stands by while a machine is being set up, or repaired, it is considered to be in operation. If there is no work to be done by the machine, and the workman is assigned to another job, the machine during that period is not in operation, and there is no cost of operation (labor cost) charged against it. If the machine is operating at a high rate of production or at a low rate, so long as an operator is in attendance, it bears

a constant hourly charge of operation. The operation cost per piece, however, will vary inversely with the hourly rate of production.

V. THE COST PER UNIT OF OUTPUT RESULTING FROM A SPECIFIC OPERATION

The hourly burden to possess and service a productive machine as formulated above is

$$\text{Hourly burden} = \frac{I \cdot p + S}{N} = B$$

The accuracy with which the hourly burden is estimated depends not only on the accuracy with which the factors I, p, and S are determined but also the accuracy of the estimate of the number of hours per year (N) during which the machine is expected to operate. In the majority of cases, N = the number of hours the department or the factory operates during the year. If a 40-hour week is observed, N is approximately 2,000 hours. However, if the factory is operated by two 8-hour shifts, it is in operation for 4,000 hours per year. If R represents the rate of hourly production, that is, the number of units or parts operated on by the machine in the hour, then the hourly burden charge per unit of output becomes

$$\frac{I \cdot p + S}{N \cdot R} = \frac{B}{R}$$

In the above example, in which

$$\begin{aligned} I &= \$10{,}000 \\ p &= 25\% \\ S &= \$1{,}000 \\ N &= 2{,}000 \text{ hours} \end{aligned}$$

the hourly burden is $1.75.

If the rate of hourly product R varies from 20 to 70, the hourly burden charge per unit of output varies from 8.75¢ to 2.5¢. The hourly burden charge for the entire range of rates of hourly production is shown in Figure 61 by the curve A-B.

The hourly cost to operate is the hourly labor cost L. If, in the above example, L = $1.25, then as the rate of production varies from 20 to 70 per hour the labor content of the cost per unit of output varies from 6.25¢ to 1.8¢. The labor content of the cost per piece for the entire range of rates of hourly production is shown in Figure 61 by

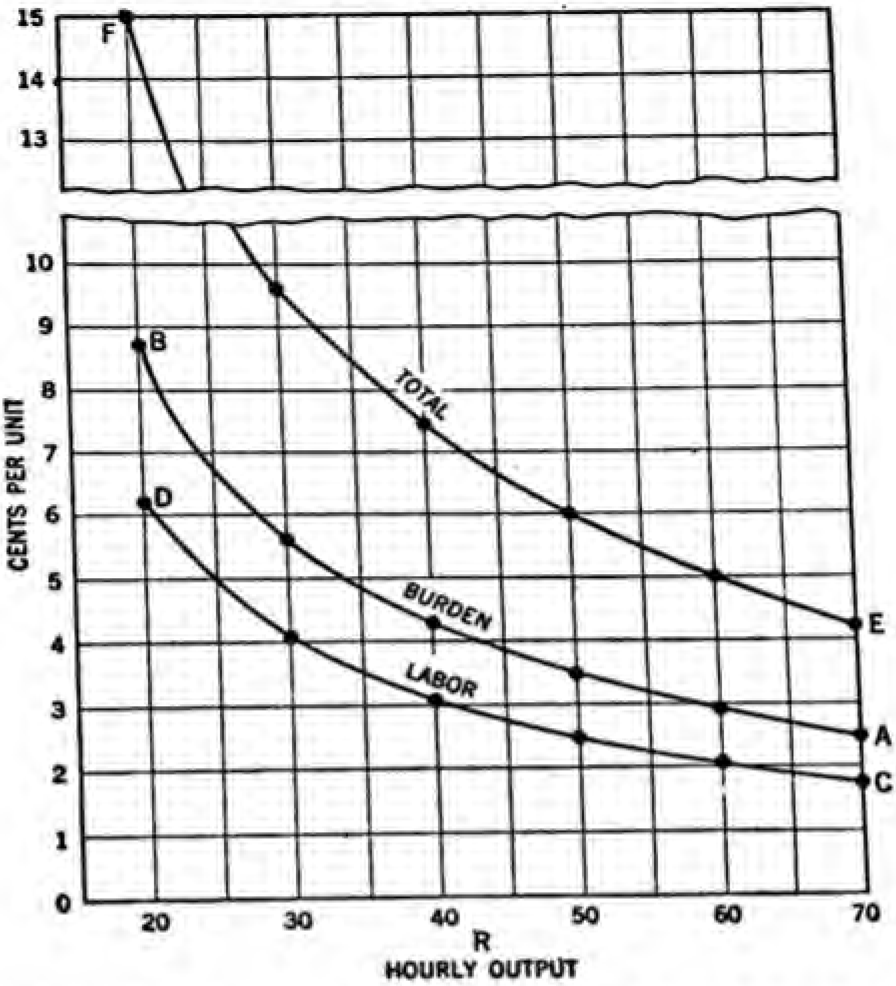

Figure 61. General Pattern of Cost of Labor, Burden and Total Cost, per Unit of Output, at Different Rates of Production of a Machine Where Labor Is in Constant Attendance

the curve C-D. The total cost per unit of output for the entire range of rates of production is shown in Figure 61 by the curve E-F. In this example, which is typical of many machine shops, it is found that the hourly burden charge is larger than the labor charge and indicates the importance, in cost finding, of the careful estimate of the hourly burden on the machine.

VI. THE COST PER UNIT OF OUTPUT AS AFFECTED BY THE CONDITIONS OF OPERATIONS

The condition under which a machine operates or is used in the factory must be taken into account in estimating the cost per unit of output by its use. Among these conditions are the following:

a. The machine is operated for N hours per year but at varying rates of output per hour, according to how it is loaded. For example, a molding press in which a maximum of 10 molds may be accommodated is operated with from 2 to 10 molds, according to its production schedule. The costs per piece of its output vary as shown in Figure 61. Or the machine is a universal machine tool such as a drill press, which, when operating on a given part, can produce 60 per hour, but when operating on another can produce only 20 per hour. The labor cost, the burden, and the total cost for each such part may be found by such a chart as shown in Figure 61.

b. A special purpose machine, adapted to, say, internal grinding of a particular part of a product such as the socket of a transit, when operated is run at full capacity or at maximum rate of production. But as the demand for the product varies, the hours of use of the machine will vary. When the machine is not in operation, the workman who operates it is assigned to work at another job. In such a case, assume that the machine costs \$10,500 and the workman receives \$1.50 per hour, and that the number of pieces produced per hour is 3. Also, it is estimated that $p = 20\%$.

As the demand on the machine varies from 10 to 40 hours per week, or from 500 to 2,000 hours annually, the burden charge per hour will vary from

$$\frac{\$10{,}500 \cdot 0.20}{500} = \$4.20$$

to

$$\frac{\$10{,}500 \cdot 0.20}{2{,}000} = \$1.05$$

Since the machine produces 3 units per hour, the burden charge per piece varies from \$1.40 to \$0.35.

The labor charge per piece, however, is constant for all demands of use of the machine and is $\$1.50 \div 3 = 50¢$.

The total cost per piece, as well as the labor and burden charges, will vary with the hours per week demand on the machine for the above conditions of operation as shown in Figure 62.

The cost of performing a unit operation on a piece part can be conveniently symbolized by the letter c. In summary, the cost of performing a given operation by the use of a given machine may be symbolized as

$$c = \text{cost per piece} = \frac{I \cdot p + S}{NR} + \frac{L}{R}$$

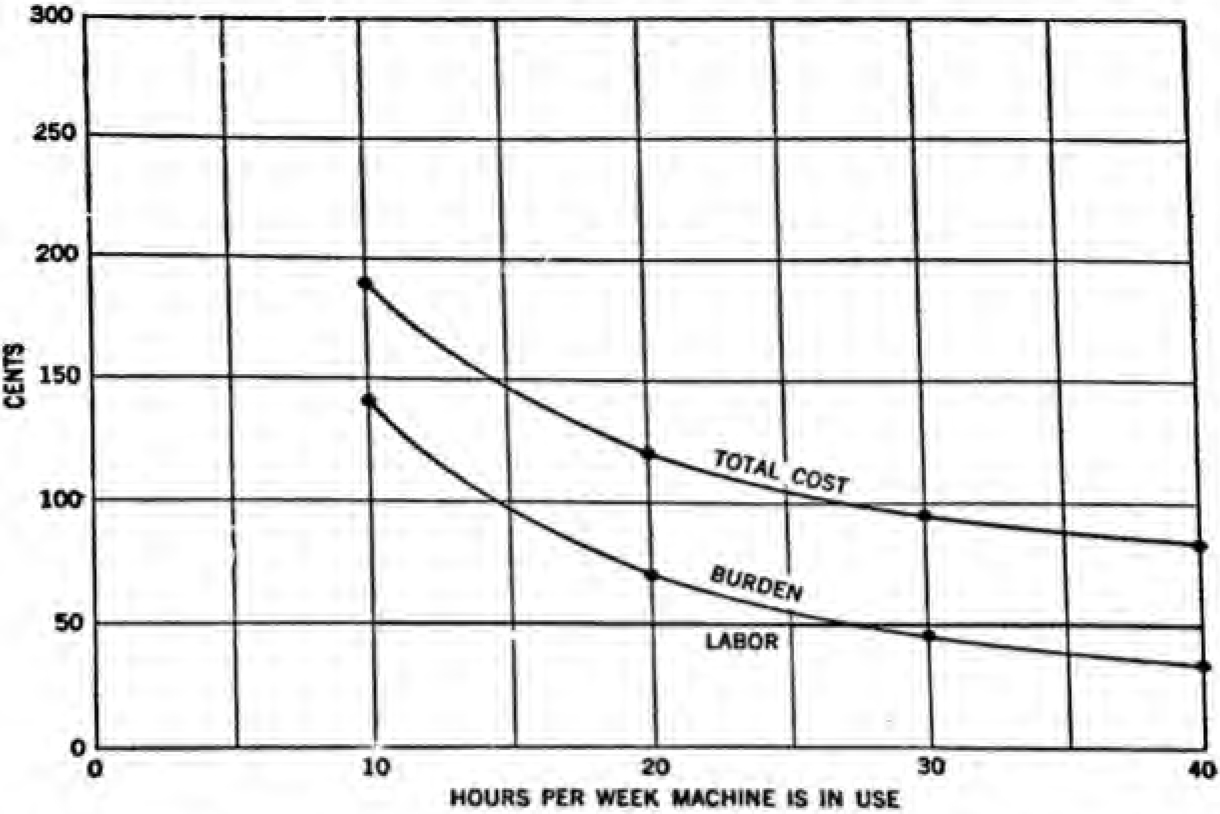

Figure 62. General Pattern of Costs per Unit of Output of a Machine Which Is Always Run at a Fixed Rate but for a Different Number of Hours per Week

VII. THE COST OF A FINISHED PIECE PART

The cost of a finished piece part is the sum of the costs resulting from each unit operation performed upon it plus the cost of the material from which the part is made.

Let

$$m = \text{material cost of the piece part}$$
$$\Sigma\,(c) = \text{the sum of the costs of each unit operation performed on the piece part}$$

and

$$f = \text{the cost of the finished piece part.}$$

Then

$$f = m + \Sigma\,(c)$$

VIII. THE COST OF A FINISHED MACHINE

The cost of a finished machine is composed of (1) the sum of the costs of the piece parts, and (2) the sum of the costs of the assembly operations per machine.

Let

$F = \Sigma\,(f)$, the sum of the costs of the piece parts
$A = \Sigma\,(a)$, the sum of the costs of the assembly operations per machine
$M =$ the cost of the finished machine

Then

$$M = \Sigma\,(f) + \Sigma\,(a)$$
$$= F + A$$

IX. APPLICATION OF THEORY OF UNIT COSTS

The worth of the above formulations of costs depends upon both the accuracy of estimates of the quantities used in the formulas and the merits of the managerial decisions that are being taken after giving consideration to these formulas.

The accuracy of estimates must be checked at regular intervals. In estimating materials cost, for example, the amount of waste in the use of the material should be checked periodically. The extent to which the waste may be reclaimed or sold and credited to operations must be reviewed from time to time. It is also important to compare the service costs assessed each month to the cost of the product with the actual service costs incurred by the department. In other words, cost records should be so organized that up-to-date information is always available for use in cost estimating. Too often cost estimating is based on data which are not representative of current operating conditions in the factory, with the result that errors in judgments, that are based on costs, frequently occur and wrong decisions are made. Cost cards should be kept up to date. In the process industries, it is usually important to have complete up-to-date data for every machine or piece of equipment used in performing a major process. The cost to possess and the cost to service the machine or equipment expressed in terms of the hourly burden should be carefully and completely estimated and the data kept up to date. In the mechanical manufacturing industries of the machine shop type, particularly where the machines in a given department are quite similar so far as the hourly burden charge is concerned, it is sufficient to pool the costs to possess and to

service all the machines of the department and to set up an hourly departmental burden in terms of the anticipated production hours of the department. For example, if the monthly burden of the department is estimated to be $10,000 and the department employs 50 men at productive labor, who together will put in 8,000 hours per month, then the hourly burden to be absorbed by each job will be $1.25 per hour for each hour of productive labor performed on it. The *anticipated* production hours must later on be compared to the *actual* ones.

Assuming that such requirements are being fulfilled and that the methods selected are being well adapted to the business in which they are being applied, it can be said that the unit costs constitute a reliable estimate of what it actually costs to produce any given item.

The question remains, however, of the adequate use of such an estimate when making high-policy decisions. Some aspects of this problem will be discussed in the following chapter when studying the relative worth of alternatives, the economic lot size, and linear-programming methods. We will now review the problems that specifically involve the cost per unit of output in relation to pricing policies in all types of industries and sales control policies in the multi-product industry.

A. PRICING POLICIES

In our competitive economy, pricing policies are, by necessity, based primarily upon market conditions. In a well-managed business, however, they should always take into consideration the cost per unit of output. By adding to this cost an average margin of profit considered as a desirable goal, it is possible to compare the actual price per unit considered as realistic in relation to market condition with the price per unit considered as realistic in relation to the ultimate goal of running a business at a profit.

Some variance between the two is to be considered normal. It should also be borne in mind that some items may be sold at a deficit, as long as this is done with the full knowledge of the situation and in view of other factors such as customers' good-will or the need for stimulating the sales of other profitable items, which in management's opinion justify such a decision.

Another reason for management to introduce some flexibility in its pricing policy is the application of the *marginal theory*, better known in cost accounting as the *direct costing* method.*

* For more details on the subject, see Villers, *The Dynamics of Industrial Management*, pp. 360*ff*. and p. 371*n*. See also David S. Fields, "Sales Mixture Control," in *The Controller*, May, 1955.

The direct costs are those that can practically be recorded and assigned to the manufacturing and sale of a product and are of such a nature that if the product was not manufactured and sold, they would not be incurred by the business.

Thus, it may be considered that the sale of any unit at a price below its list price but above its direct cost improves the total profit as long as it is true that:

1. It could not be sold at a higher price;
2. Its sale at a low price does not affect unfavorably the other sales.

The problem of dumping. When a businessman sells his products in another country than his own at the approximate cost of manufacturing and handling, he is said to be dumping his goods on the foreign market. By so doing he does not disturb the price situation in the home market, unless the goods are re-exported and sold at home at less than domestic prices. He also increases his total profits over that which he would have if he did not produce and sell in the foreign market, even though he may sell these goods abroad at prices less than their total unit cost. This situation may be studied by means of a curve of unit costs related to a single item or to a given group of items fully comparable to each other from the cost point of view.

Suppose, for example, that the unit-cost curve of a business is as shown in Figure 63. When the business is operating at 60 percent capacity, the cost per unit of product is \$8.80. At a selling price of \$10 there is a profit of \$1.20 per unit. Let us assume that this product may be sold abroad in considerable quantities at \$5.50, f.o.b. plant. By selling abroad at this price, the manufacturer finds he can operate his plant at full capacity and that the product now costs \$6.00 per unit to manufacture. How can the manufacturer afford to sell the product abroad at \$5.50 when it costs \$6.00 to produce it?

It is true that there is a loss of 50 cents on all articles sold abroad, and that this loss is encountered on 40 percent of the plant output. On the other hand, if the domestic market takes 60 percent of the plant output, the cost of production will be lowered from \$8.80 to \$6.00 per unit. Therefore the profits on the domestic business will be increased by \$2.80 per unit of product on 60 percent of the plant output and there will be a loss of 50 cents per unit on 40 percent of the plant output, but the result is an increase in total profits. The net increase in profit per unit on the domestic business will be

$$\frac{(60 \cdot \$2.80)}{100} - \frac{(40 \cdot \$0.50)}{100} = \$1.48$$

Whether or not dumping on a foreign market is a good business policy to pursue is another matter.

Some manufacturers follow a somewhat similar approach when marketing their products on the national market under different trade names. It is well known that some manufacturers, especially in the consumer goods market, are simultaneously selling some of their

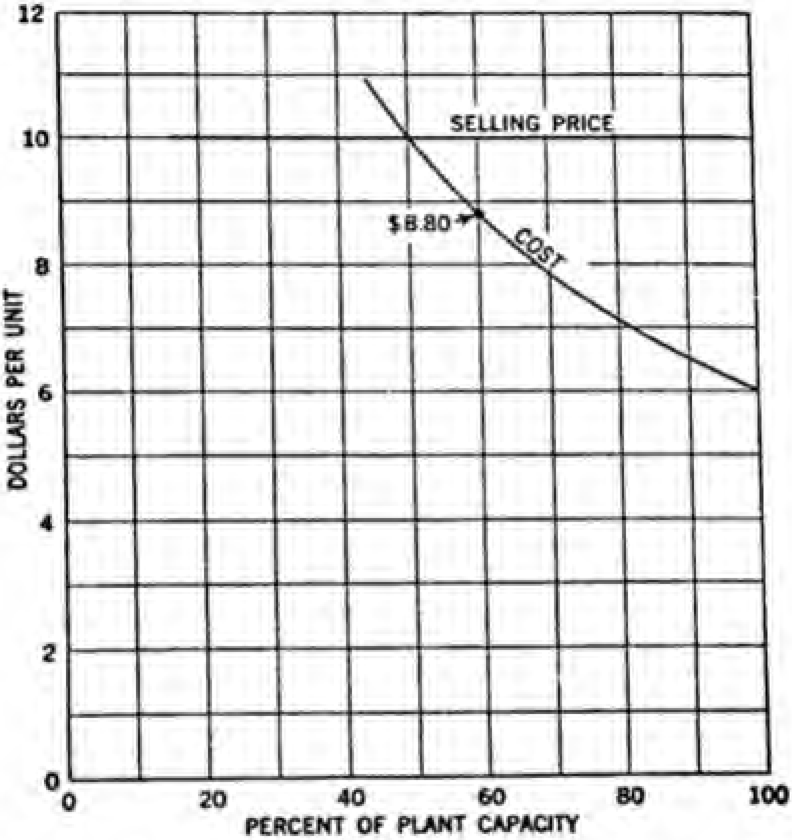

Figure 63. The Unit Cost in Relation to Selling Price

products at a high price and a low price under two distinct trade names. The trade name and some slight differences in their presentation (packaging, color, etc) are the only factors that distinguish the highly priced item from the low priced one. From every other point of view—quality, usefulness, etc.—they are identical. In recent years, this practice has often been followed by manufacturers who want to sell a large volume of goods at comparatively low price through controversial distribution channels, such as discount houses, without losing their primary market, namely the traditional distribution channels of wholesalers, retailers, and department stores.

Pricing in an automatized plant. In recent years, the use of automatized equipment has raised a new and very interesting problem in determining the cost per unit of output.

The traditional elements of cost are all to be found in the automatized plant. direct labor, direct material, depreciation, services, and other elements of cost. What is new is the fundamental change in the relative importance of these various elements. The cost of possessing the equipment is so high that all of the other elements of cost tend to lose their importance as compared to the cost to possess. The result is that the direct-labor wages, the waste of material, the cost of overtime, and all of those cost factors that are normally given primary consideration tend, at least in some cases, to become almost insignificant with the advent of "automation."

The writer had recently received the assignment of determining a formula to be used for pricing purpose in an almost fully automatized plant. He found that the greatest problem in this case was the cost of "non-operation" rather than the cost of operation. What is meant by this is that the cost of possessing such expensive equipment was so out of proportion with the other elements of cost, such as direct labor, waste of material, overtime, etc., that the main and in this case the only real problem was to reduce the idle time of the equipment to its very minimum. It is thought that this situation will be found in an increasing number of plants in the years to come. In fact this explains in part the increasing attention presently given to the methods of linear programming. One of the main purposes of these methods which will be reviewed in the following chapter is precisely to optimize profit by minimizing the idle time of the plant facilities.

B. SALES CONTROL IN THE MULTI-PRODUCT INDUSTRY

The multi-product industry can be defined as the one in which the number of items manufactured and sold is such that it precludes sales control on a strictly individual basis, item by item. In some businesses, like the Bausch and Lomb Optical Company for instance, the number of items exceeds 180,000; but the problem exists as soon as it reaches about 100 different items.

For the purpose of pricing, it is necessary to consider each item individually. This is a practical solution because pricing is done for the whole business and is done once and for all, subject only to occasional revision. Sales control on the contrary must be exercised for each sales district and even salesman by salesman. In addition, it must be done at frequent intervals: on a monthly or even a weekly

basis. It therefore requires procedures of a synthetic character to get an over-all view of the situation.

One method that has gained increasing acceptance in recent years is based upon the deliberate segregation of sales-volume control from sales-mixture control.

The sales-volume control merely adds the total sales, by salesmen, by sales district, and for the business as a whole, for the day, the week, the month, and the year.

The sales-mixture control is an evaluation for the business, the district, or the salesman of the value of the volume sold in terms of profit. It seems advisable to base this control upon an evaluation of *direct profit,* i.e., the difference between selling price and direct cost rather than upon an evaluation of the net profit for each item sold. The fundamental reason for this approach is that the part of overhead that is supported by some of the products sold—let us call these products of Group A—would have to be transferred to other products, such as those of Groups B and C either totally or in part, should the sales mixture not include any product of Group A or should the assumed percentage of Group A products in relation to total sales be less than anticipated. The result is that to evaluate the final consequence of a change in the sales mixture, for instance a decrease in the sales of Product A, it would be necessary to recompute the burden of all the products of the Groups B, C, etc.

It seems desirable therefore to separate the control of the sales mixture from the control of the total sales volume. It should of course be kept in mind that they should both be exercised simultaneously, although separately.

To relate the sales-mixture control to the sales-volume control in quantitative terms, the method of differential-profit control, previously discussed in Chapter IV, provides the necessary mathematical model. The sales-mixture chart also discussed in Chapter IV provides a graphical representation for the purpose of sales-mixture control.*

* See above pp. 111*ff.*

XIII

RELATIVE WORTH OF ALTERNATIVES

THE ULTIMATE goal of management from an economic point of view is to maximize the profit of the enterprise. This goal cannot be reached by merely following a "well-established routine." It constantly requires decision-making to choose between various possibilities. Rarely, if ever, is the choice to be made between a "good" solution and a "bad" one. Should this machine be replaced by this new model? If the old machine was definitely obsolete or worn out and the new one offered at such a price that it would quickly pay for itself, there would be no problem. The chances are, however, that the situation is much more complex; the new machine may require a change in the process, the old one could be improved by spending a reasonable amount of money, the new one may soon be made obsolete by some research work now undertaken, etc.

This need for decision-making does not always occur in terms of high-policy decision. It also has to be faced every day and in fact many times a day. Should this salesman be sent South or should he

first go to the West Coast? Should that order be accepted from this customer, although it means changing our production schedule? Or should we refuse it?

Ultimately decision-making is management's responsibility and it always involves in part some arbitrary decision. The reason is that a quantitative analysis of the relative worth of alternatives cannot possibly take into account all of the factors involved. This is so because some factors could not be quantitatively determined with complete accuracy (such as customer good-will), because some factors involve an element of uncertainty (such as future sales of any given product), and because some of the relationships involved are so complex that a quantitative determination of all of the impacts of any given decision would sometimes be impractical.

Since the very start of the scientific management movement at the turn of the century great efforts have been made to provide a quantitative analysis of the relative worth of alternatives. In recent years, the trend has definitely been toward improving and extending the techniques available. In this chapter we will briefly review the techniques that have been developed over the years to provide management with a quantitative analysis of the relative worth of alternatives.

It should always be kept in mind that none of these techniques gives the final answer. They can only provide information. This information can serve as a basis for managerial decisions, which can thus be based upon rational considerations instead of upon intuition and feelings. These techniques, however, do not eliminate the need for some risk-taking and for some arbitrary decisions. They do not constitute a substitute for management.

I. THE DETERMINATION OF THE RELATIVE WORTH OF SEVERAL COMPETITIVE MACHINES

A. TECHNICAL CHARACTERISTICS

The determination of the relative merits of two machines has been one of the first problems to receive attention when attempts were made to provide quantitative data for determining the relative worth of alternatives.

Many years ago, one of the writers had occasion to inquire into the relative merits of two lathes for use in rough-turning forgings. The problem posed was: Which one had the greater over-all capacity for removing the greater volume of metal in the shorter period of time? This was important to know before comparing prices. Some method

for measuring this capacity had to be applied. The method used was that devised by the late J. T. Nicholson and published in his excellent treatise on "Lathe Design."*

The capacity of a lathe for rough turning depends on the speed and the area of cut it can take on all diameters of work it is able to swing. The area of cut in turn will depend on the torque which may be delivered to the spindle. Accordingly, it appears that, if a torque-speed diagram is set up for each lathe, their relative capacities for doing rough turning may be judged by a comparison of these diagrams.† Such a comparison is shown in Figure 64 from which it is

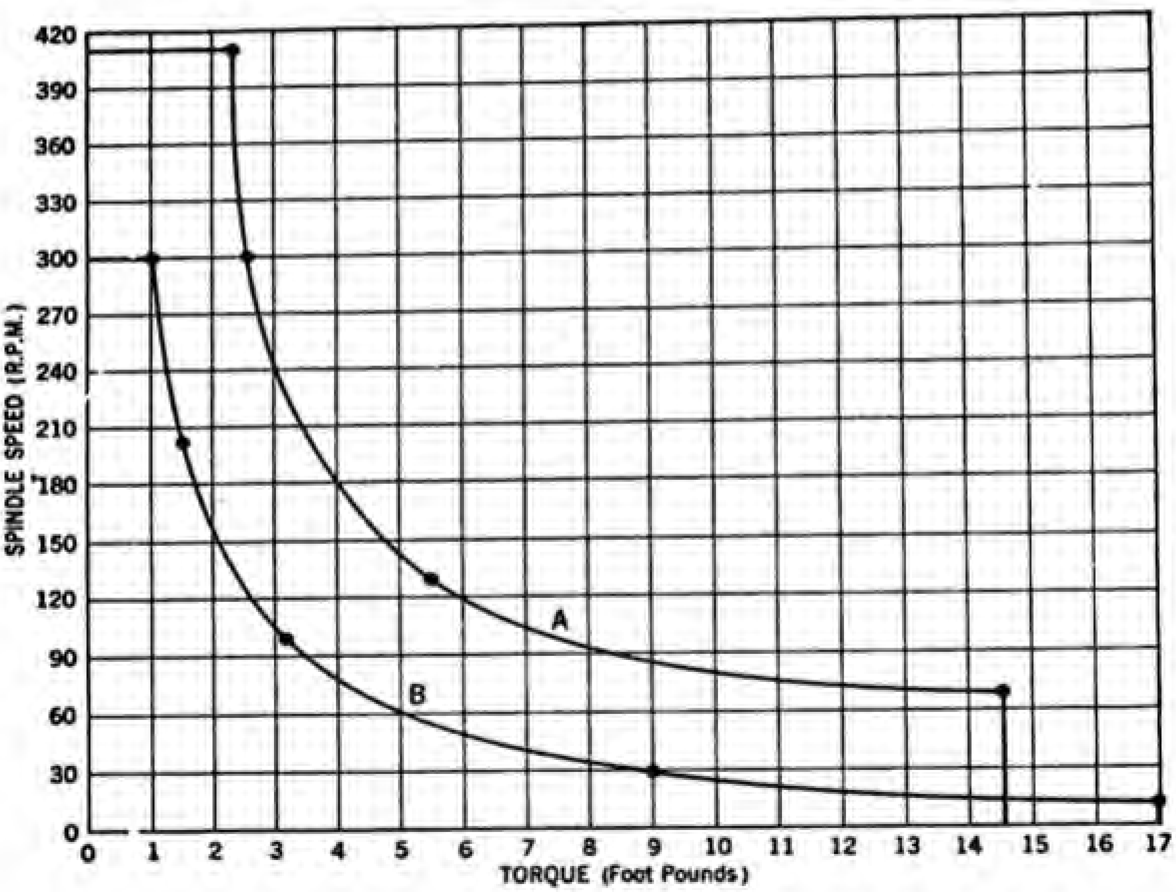

Figure 64. The Speed-torque Characteristics of Two Lathe Headstocks

seen that Lathe A is much superior to Lathe B in capacity to remove metal in roughing operations. The price of each lathe divided by the area of its corresponding speed-torque diagram gave a rational comparison of price per unit of capacity for rough turning.

* Longmans, Green and Co., Ltd., London.

† "A Comparison of Lathe Head-Stock Characteristics," by Walter Rautenstrauch, *Journal A.S.M.E.*, Vol. 32, January-June, 1910.

B. ECONOMIC CHARACTERISTICS

The relative worths of several machines which are each equally adapted to performing a specific service may be determined by comparing the cost per unit of output of each.

In Chapter XII the factors of cost per unit of output were defined and formulated as follows:

$$c = \text{cost per unit of output}$$
$$= \frac{I \cdot p}{N \cdot R} + \frac{S}{N \cdot R} + \frac{L}{R}$$

where

I = the investment in the machine

p = the annual percentage of fixed charges which is the sum of the percentages of the investment representing the annual charges for insurance, taxes and depreciation

N = the number of hours the machine is to be operated during the year

R = the rate of production per hour, that is, the number of units of output the machine is capable of producing in the hour

S = the annual service charges to be borne by the machine during the year

L = the hourly wages of labor engaged in operating the machine

The following example will illustrate how this formula is used in determining which of two machine tools capable of doing the same job is to be preferred.

a. *Both machines used continuously throughout the year.* Two machines, A and B, are available for performing a given operation. They differ in investment, in the rate of production, in the skill of the operator, and in the cost to maintain (hourly service charge). They compare as follows:

Item	Machine A	Machine B
I = investment	$4,000	$6,000
p = annual percentage of fixed charges	17%	20%
L = hourly wage	125¢	110¢
$\frac{S}{N}$ = hourly service charge	90¢	90¢
R = pieces per hours	5	8
N = annual shop hours	2,000	2,000

Accordingly, for Machine A

$$c = \frac{400{,}000 \cdot 0.17}{2{,}000 \cdot 5} + \frac{90}{5} + \frac{125}{5} = 49.8¢$$

For Machine B

$$c = \frac{600{,}000 \cdot 0.20}{2{,}000 \cdot 8} + \frac{90}{8} + \frac{110}{8} = 32.5¢$$

Therefore, Machine B, while higher in first cost (investment), has the greater economic worth since it can produce at a lower cost per piece.

b. *Limited annual production, neither machine available for other purposes.* This situation arises with special purpose machines such as one designed to machine a valve body preparatory to the insertion of the valve seat. If the annual production of valves declines, the machine, not adaptable to other purposes, is idle.

Assume that the above machines are of this character and the annual production of the shop is 10,000 valves per year. In this case, Machine A, with a rate of production of 5 per hour, will be running full time (2,000 hours per year). Machine B, however, will run only 1,250 $\left(\frac{10{,}000}{8}\right)$ hours per year or 62.5% of full shop time.

This will result in increases in the hourly cost to possess per operating hour and the service charge per operating hour. Hence

$$c = \frac{600{,}000 \cdot 0.20}{1{,}250 \cdot 8} + \frac{90}{8 \cdot .625} + \frac{110}{8} = 43.75$$

And so although Machine B is to be idle 37.5 percent of the time, it still is a better buy, and for an annual production of 10,000 pieces per year there will be a saving in cost of $605 per year.

II. ECONOMIC LIFE SPAN OF MACHINERY

What has come to be known as Kelvin's law was derived by Lord Kelvin, the eminent English physicist. Kelvin observed that the problem of constructing a power transmission line involved an interesting relation between the investment in the line and the power losses in transmission. The larger the wire the greater the investment, and hence the greater the fixed charges, but also the lower the transmission losses. In that event, Kelvin reasoned there must be some size at which the sum of the fixed charges and the cost of the transmission losses is a minimum. To find this minimum cost size, he set up a formulation which provided a determination of this minimum by differentiating.

Kelvin's law applies to the problem of determining the most economic life span of machinery. The factors involved are as follows. The annual depreciation of the investment (I) is $\frac{I}{N}$ where N is the number of years of the life span. Thus a machine costing \$100,000 if it is to be retired in 5 years will be depreciated at the rate of

$$\frac{\$100{,}000}{5} = \$20{,}000 \text{ per year}$$

If the machine is to be retired after 4 years, it will be depreciated at the rate of \$25,000 per year. The annual cost of operation of machinery is usually a constant (C) plus an increasing annual increment for repairs and maintenance (R). Thus after 3 years, for example, the cost of operation will be C + 3 R and after 5 years it will be C + 5 R.

Accordingly, the total annual cost (T) will be:

The annual fixed charges (k) which is constant

The annual depreciation $\left(\frac{I}{N}\right)$

The constant annual cost of operation (C)

The annual cost of repairs and maintenance (NR) which increases with the years.

Thus the total annual cost (T) becomes

$$T = K + \frac{I}{N} + C + NR$$

This is a minimum when

$$\frac{dT}{dN} = 0$$

Accordingly,

$$dT = 0 - \frac{I}{N^2}\,dN + 0 + RdN$$

or

$$\frac{dT}{dN} = -\frac{I}{N^2} + R = 0$$

$$N = \sqrt{\frac{I}{R}}$$

In recent years extensive research work has been undertaken in an attempt to include other factors, such as interest, taxes, possibilities

of other investments, and comparative cost of operations, into the above formulation. To some extent, the matter is still in the development stage and is even a controversial subject.*

III. THE ECONOMIC LOT SIZE

The problem of determining the economic lot size has become more important in recent years in view of the development of the multi-product industry, and it has become more complex with the growth in size of the average plant in each branch of industry. This problem, of course, arises in shops which put parts in production by batches or lots of parts. In such shops, the practice is to use universal machines adapted to operating on lots of parts by the use of cutters, fixtures, or jigs, which are especially set up for each lot of parts.

In intermittent manufacture a machine of the general purpose type, such as a milling machine, is used to process a sequence of lots of parts. Each process in the sequence is different and requires a special set-up. The cutters and fixtures used on a lot just finished must be removed, and new cutters and new fixtures must be installed for the processing of the next lot. The set-up is usually made by a highly skilled mechanic and may take several hours of his time. A less skilled operator, after the set-up is made, is then assigned to the job of processing the lot.

The time required to make a set-up may be two hours. In that case, the cost of the set-up consists of the wages of the skilled mechanic, say two hours at \$1.50 per hour = \$3.00; plus the hourly burden of say \$1.00 for the two hours "down time" = \$2.00. This \$5.00 charge for preparing the machine must be borne by the lot to be processed. If there are 50 pieces in the lot, this will mean 10¢ set-up charge per piece. If only 25 pieces, there will be a set-up charge of 20¢ per piece. If 100 pieces, it will be 5¢ per piece.

The larger the number of pieces in the lot, the smaller the set-up charge per piece. If a manufacturer required a given process to be performed on 1,200 pieces in a year, and he processed the whole lot with one set-up of the machine, the set-up cost per piece would be

* For an extensive study of the subject, see G. W. Terborgh, *Dynamic Equipment Policy*, McGraw-Hill Book Company, 1949. For a discussion of the matter and a presentation of some new suggestions, see R. O. Swalm, "Machine Replacement Analysis," in *Journal of Industrial Engineering* (Jan., 1955), and R. W. Pinger, "Another Approach to Machine Replacement Analysis," in *Journal of Industrial Engineering* (Nov., 1955). See also, R. B. Orensteen, "Topics on the Mapi Formula," in *Journal of Industrial Engineering* (Nov.-Dec., 1956).

less than if he should process a lot of 100 each month. Processing a lot of 100 each month would require 12 set-ups to process the annual requirements of 1,200 pieces. It would also require 12 times handling of materials (scheduling, routing, and dispatching) and therefore cause additional-clerical costs. It is apparent, however, that while the set-up charge per piece is a minimum when the entire annual requirement is processed with one set-up, the ratio of the average annual investment of capital in inventory to annual sales will be a maximum. This means that not only is the earning power of the dormant inventory not being realized, but also there are added expenses incurred in maintaining greater storage capacity.

Accordingly it appears that as the lot size increases, the set-up charges and the clerical costs per piece decline while the idle capital and housing costs increase. At some point in size, the sum of these costs is a minimum. That point establishes the economic lot size. The determination of this quantity (lot size) apparently depends on the quantitative determination of the costs of set-up, clerical work, idle capital, and housing. If these costs cannot be determined with reasonable accuracy, all we have is a nice theory which cannot be applied. To those who have their costs of operation so organized that the above costs can be determined, the following formulation of the theory of the economic lot size will be of interest:

Let

$N =$ the number of pieces to be produced annually

$Q = \frac{N}{k}$, the economic lot size where k is 2 or 3 or 4 or 5, etc.

$R =$ the annual cost of housing the average inventory to be carried and the interest charges on the investment in inventory *when the whole annual requirements are produced in one run*

$r = \frac{R}{k}$

$z =$ the cost of one set-up and dismantling and the cost of clerical and other services incidental to starting a production order

$Z = zk$

The best value of Q occurs when the sum $Z + r$ is minimum, that is, when the sum $zk + \frac{R}{k}$ is a minimum.

Let this sum be M. Then the best value of O is had when:

$$\frac{dM}{dk} = 0$$

or

$$z - \frac{R}{k^2} = 0$$

and hence

$$k = \sqrt{\frac{R}{z}}$$

But since $k = \frac{N}{Q}$, then

$$Q = \frac{1}{N\sqrt{\frac{R}{z}}} = N\sqrt{\frac{z}{R}}$$

Example:

Assuming that for a given set-up to process a lot of 50,000 parts, it costs $25.00 (z) to set up and dismantle the machine and put the lot in production and that the annual cost of housing the average annual inventory to be carried, including the interest on the investment in the inventory, for processing the whole lot (50,000) in one run is $500, then the economic lot size is

$$Q = 50{,}000\sqrt{\frac{25}{500}}$$

$= 10{,}000$, the nearest uniform lot quantity

It must be emphasized of course that the accuracy of the estimate of the economic lot size depends wholly on the accuracy of the estimate of the items of cost which enter into the formula. When such cost estimates are attempted, it is sometimes found that the accounting system in use is not adequate to estimating the necessary items of cost.

This approach has been criticized in recent times as being too narrow, and as not taking into account several other factors that should be taken into account in determining the economic lot size, such as the use that could be made of the machine if it was used for another purpose or the need for relating the lot size to more general considerations involving production scheduling, sales forecasting, etc.*

Such considerations are related to the recent trend toward enlarging

* For a new approach to the problem, see M. E. Salveson's "A Problem in Optimal Machine Loading," in *Management Sciences*, April, 1956. This article originally presented as a paper before the Annual Meeting of the Institute of Management Sciences and based upon an actual case is now generally recognized as constituting pioneering work in the field.

the basis upon which the relative worth of alternatives can be determined. This recent trend will now be considered.

IV. OPTIMIZING THE CONDITIONS OF OPERATIONS

During World War II, military strategists found it useful to cooperate with scientists in determining their plans of action. The techniques they used have become known as "Operations Research."

After the war, it was realized that these techniques, after proper adjustments, could be adapted to the fundamental problem of maximizing the profit of the business enterprise by optimizing the conditions of operations.

The Scientific Management Movement which started at the turn of the century had precisely directed all its efforts toward the solution of this problem and, to that extent, it can be said that it had preceded the techniques of Operations Research.* In fact, in recent years, the true perspective of this historical evolution has been emphasized in the writings of highly qualified experts in the field.

George P. Champion, Senior Operations Research Analyst, Lockheed Aircraft Corp., in an article titled "A Continuation of the Best in Industrial Engineering," † made the following statement:

> In February of this year (1956) an article in *Fortune* Magazine (by H. Solow) said: "Operations Research is an applied Science, or perhaps a branch of engineering—some predict that the name Operations Research will fade out, while its proved virtues will be absorbed into industrial engineering." If this should become true, it would be because operations research is a continuation of the best in Industrial Engineering. Let's see why this is so.

The author of this article then proceeds to show—and convincingly so in the writer's opinion—why it is true that Operations Research can be considered as "a continuation of the best in industrial engineering." Further difficulties have arisen from the fact that the relationship of such techniques as "linear programming" or "mathematical programming" with operations research or industrial engineering does not either escape controversy.‡

* For a more detailed study of this historical evolution, see Villers, *The Dynamics of Industrial Management,* Part I, especially pp. 72 and 93*ff*.

† *Journal of Industrial Engineering*, July-August, 1956. For more information, see the extensive bibliography at the end of this article. For a presentation of the history and development of operations research techniques, see McCloskey and Trefethen, *Operations Research for Management* (Part I), Johns Hopkins University Press, 1954.

‡ For a detailed study of linear program concepts see Charnes and Cooper, *An Introduction to Linear Programming*. John Wiley and Sons, Inc., 1953.

In final analysis, it seems that much of the controversy that has arisen is related to the terminology used rather than to anything else. It is to be hoped that in the years to come this terminology will be clarified. In the meantime, it can only be stated that great progress has been made in understanding the fundamental problem of relative worth of alternatives and in using mathematical methods to determine the quantitative analysis of this problem.

Such progress is related to the increasing use of electronic computers, which have made it possible to use computation methods which otherwise would not have been even considered. As a result, it has been possible for management to cope with problems of increasing complexity of production scheduling, inventory control, salesmen's traveling, warehousing and many others in the most diversified fields.*

The various methods used are themselves vastly diversified. Speaking in general terms, for the purpose of gaining an understanding of these recent developments, it seems possible to provide a description of the methods that have been proposed by noting that they all recognize the need for *five fundamental steps* in proceeding with the analysis and measurement of the relative worth of alternatives:

STEP 1—*Selecting the factors.* An attempt is made to select the single factors that can be considered as influential in determining the relative worth of alternatives. This selection is based upon a study of past records which in many cases will provide an indication of the fact that a change in this or that factor was influential. It should be recognized, however, that this selection also requires common sense and experience. To illustrate: the price of a product is an obvious factor that influences the sales volume. Less obvious factors also deserve attention, such as the packaging of the product. Furthermore, factors that are only indirectly related must also receive consideration. For instance: the fact that if a given product A was not manufactured, then the profit P_A made on that product would be lost, but maybe the equipment would then be available to manufacture product B and maybe the profit P_B on product B would be greater than P_A.

STEP 2—*Evaluating the selected factors quantitatively.* An attempt is made to provide quantitative information related to each of the influ-

* For a comprehensive presentation of case histories, see McCloskey and Coppinger, *Operations Research for Management*, Vol. II, Johns Hopkins University Press, 1956. For specific studies see, among others: J. F. Magee, "Guides to Inventory Policy," in *Harvard Business Review*, Jan.-April, 1956; M. E. Salveson, "The Assembly Line Balancing Problem," in *Journal of Industrial Engineering*, May-June, 1955, and his, "A Problem in Optimal Machine Loading," in *Management Science*, April, 1956.

ential factors thus selected. Statistical methods, and specifically the probability theory, are being used extensively to provide such quantitative information. For instance the queuing theory may provide data related to the waiting time of customers on a telephone line.*

STEP 3—*Interrelating the selected factors.* An attempt is made to provide an abstract representation of the system under which such factors are likely to combine their influence as they, independently or simultaneously, change in value. To use an analogy: if a given stone is pulled in ten different directions by ten groups of people of varying physical characteristics, the application of vector analysis will provide quantitative information as to the direction that the stone will take, assuming that the pulling strength of each group is properly determined. In such a case a *mathematical model* developed by the use of vector analysis provides an abstract representation of the system and makes it possible to proceed with computations related to the direction taken by the stone and based upon the determination of the pulling strength of each of the ten groups at any given time. These pulling strengths may change from time to time, but the model remains valid.

Vector analysis was suggested as an analogy because many of the most recent mathematical models proposed for the solution of production problems are based upon matrix algebra, an n-space vector analysis.†

The terminology "mathematical model" does not always reflect the true character of the model proposed as an abstract representation of the system constituted by the interaction of the factors that have been selected for consideration. The term *analog model,* which implies the possibility of using an analogy for the purpose of gaining quantitative information related to a given problem, has been proposed, and also the term *logical model*, which indicates the possibility of determining the sequence of logical decisions as part of a model.‡

Analog models, logical models, and mathematical models cannot provide an absolutely accurate abstract representation of the relationships prevailing among the factors considered as influential upon the operations of the business enterprise. They can, however, be considered as

* See Byron O. Marshall, Jr., "Queuing Theory," in McCloskey and Trefethen, *op. cit.*, pp. 134*ff*. See also W. Feller, *An Introduction to Probability Theory and Its Applications*, John Wiley and Sons, Inc., 1950 (Vol. I).

† See, among others, M. E. Salveson, "A Problem in Optimal Machine Loading," *loc. cit.*

‡ For an extensive study of this subject, see Churchman, Ackoff, and Arnoff, *Introduction to Operations Research*, John Wiley and Sons, Inc., 1957, Chapter 7, "Construction and Solution of the Model."

a useful representation if the variance between the actual data and the quantitative information the model provides remain within limits which are themselves considered as acceptable for the intended purpose. For instance, in testing the validity of the profit and loss chart in a number of cases it was found that the variance was acceptable for the purpose of managerial control. (See above Table XX, page 132; see also pages 153, 154.)

STEP 4—*Determining the restrictions.* Certain restrictions related to the conditions of operations must be added to the model. If the mathematical model used for the computation of optimal machine loading in a given plant is a matrix, it must be associated with certain restrictions. These restrictions exclude solutions which would be provided by strict matrix algebra but are not compatible with the conditions of operations. For instance, it may be necessary to exclude any solution which would imply that the production of item No. 123 would fall below the minimum production of this item required by a previous contract with a given customer.

STEP 5—*Computing the optimum solution.* Finally, certain computing procedures are being used to determine which is the solution indicated by the model (of Step 3) and not excluded by the restrictions (of Step 4) that will provide the most desirable alternatives, i.e., the one that optimizes profit. Actually, the terminology "suboptimization" has been recommended to indicate that the optimization is by necessity bound to be an incomplete one.* The computing procedures available are very complex, and it is generally recognized that they should be simplified. As stated by Professor P. M. Morse, of Massachusetts Institute of Technology, "*Techniques of solution are not simple and many of them require high-speed computing machines; much further mathematical research is needed to simplify computing procedures in linear programming computations.*" †

It is to be expected that the needed simplification in present computing procedures will characterize the evolution in the field in the years to come. In the meantime, present computing procedures should be understood at least in general terms by the student who wants to appreciate the value and the possibilities of modern techniques in the determination of the relative worth of alternatives.

* See C. Hitch and R. McKean, "Suboptimization in Operations Problems" in McCloskey and Trefethen, *op. cit.*, pp. 168*ff*.

† P. M. Morse, "Progress in Operations Research" in McCloskey and Trefethen, *op. cit.*, p. 106.

One of the best presentations known to the writer is the study published by Dr. Melvin E. Salveson, of General Electric Company, on "Mathematical Methods in Management Programming." This study is reproduced in part here by special permission of its author.* The reader's attention is especially called to the description of the "Simplex Method" which is currently used in many instances as computational technique.†

Mathematical Methods in Management Programming

by Melvin E. Salveson

(*Journal of Industrial Engineering*, March, 1954)

The Objective Function

Let us assume that total profit is denoted by $f(x)$. Let us assume that the amount of a commodity we make is denoted by "x." Let us also identify each commodity by attaching an identifying subscript, say "i." Finally, let us denote the time at which any commodity is produced by a superscript "t," indicating, say, the day, month, or other in which it is produced and sold. For the moment, let us assume we have a reliable measure of the profit on each commodity we are to make during each time period. Let us denote this by a^t_i. Then, the total profit is equal simply to the sum of the products of the amount made of each commodity during each time period by its profit during that period. That is;

$$f(x) = {}_{t}\Sigma_{i}\, x^{t}_{i}\, a^{t}_{i}$$

Restrictions on Profit Functions

No practicing manager or engineer needs to be told that he has many limitations on his plant's capacity to maximize profits. There are limitations on the supply of capital, manpower, machine tool time, material, power, tooling, etc. At any time, any one or more of these may limit the maximum profit. Hence, in the words of the economist, we wish to "allocate" the use of his capacity of those factors which are his "bottlenecks" in such manner as to obtain the production program with the maximum profit.

Every production manager knows, of course, that time, money, and material are universal requirements. Most shops, indeed, have "standards" for the amount of each of these which is required for any commodity. These may be called by such familiar names as "time standards," "standard costs," or "bills of materials." We assume (for mathematical reasons) linear relations in these

* Fo- an extens've study of computing procedures, see among others: Charnes and Coope-, *op. cit.*, and Merrill M. Flood, "The Traveling-Salesman Problem," in McCloskey and Coppinger, *op. cit.*, Volume II, Section 19.

† The portions of the article presented here are reprinted by permission of Dr. M. E. Salveson.

requirements, i.e., for example that it takes ten times as much material to make ten units as it does to make one; ten times as long to make ten units as it does to make one, etc. This is a familiar concept, that the total requirement of any factor for making any one item is equal to the product of the unit requirements by the number to be made. In expressing this, let us use notation as before, but add a second subscript to denote which factor of production (money, machine, tool, labor, or other) we may be considering and let that be the symbol "k." Let us also use the notation "b" to indicate unit requirements. Thus, x^t_{ik} would denote the amount of the *ith* item produced during time period t using the *kth* factor of production. b_{ik} would indicate the unit requirement of the *kth* factor for producing the *ith* item. Thus, the total requirement on any one factor k in any program would be:

$$_t\Sigma_i\, x^t_{ik}\, b_{ik}$$

If all factors of production were not available in limited supply, we should not be here today to worry about the problems of production control. But, since they are, we must reckon with this fact; it is the source of ever present bottlenecks. Let us assume that we have only an amount c^t_k of any factor k during any time period t. It is common knowledge that the amount of any factor which is planned to be used must be equal to or less than the amount that is available.

This relationship we can state as follows:

$$\Sigma_i\, x^t_{ik}\, b_{ik} \leqq c^t_k$$

Empirically, it is obvious that we cannot have negative production, so we add the obvious restriction that:

$$x^t_{ik} \geqq 0$$

We define

$$x^t_i = \Sigma_k\, x^t_{ik}$$

Thus, we have our beginning mathematical problem. Maximize:

$$f(x) = \Sigma_{it}\, x^t_i\, a^t_i$$

subject to satisfying the requirements that:

1. $\Sigma_i\, x^t_{ik}\, b_{ik} \leqq c^t_k$
2. $x^t_{ik} \geqq 0.$

We can use this formulation for such problems as:

1. to determine the optimum shop load during any one time period or over several time periods.
2. to determine the optimum amount of overtime to use on any item or machine tool.
3. to determine the optimum mix of commodities to make in the shop or factory.
4. to determine the amount of rerouting of work in the shop.
5. to determine the optimum level of inventory (raw, in-process, and finished).

6. to determine the optimum distribution of production of commodities between time periods.

However, it is important to point out what this formulation will not do and what its inherent limitations are. It is not able:

1. to determine a schedule for a shop.
2. to select the best sequence of production in order to minimize, say, set up time.
3. to eliminate need for expediters.
4. to avoid all conflicts in production, such as temporary bottlenecks and, hence, its program is not necessarily always achievable (unless it is constructed with overly liberal delay allowances).
5. to give delivery dates more precisely than the length of its time periods.

It does not consider several important aspects of production, although they often may be "gotten around" by various tricks. For example,

1. It assumes certainty, i.e., it does not predict rejects, worker absence, market fluctuations, or other. These are assumed to be known on some average basis and that average is usually used in the computations. It does not provide a means for investigating the effect of perturbations.
2. It assumes linearity throughout. That is, it neglects the non-linearities of "learning" by the operator, of set up time, of increasing returns to scale in production and decreasing sales price on increasing sales volumes.
3. It assumes continuity. It neglects "lumpiness," or the fact that machine tools come in discrete units; it effectively assumes that production of all items to be produced is simultaneous and continuous during the period and that production is not complete on any item until the end of the period. (Which is why it will not select exact time or time schedules.)

It is seen, therefore, why this is termed only a beginning formulation of the problem. Nonetheless, it is highly useful. It permits better answers than are attainable by present methods for the problems to which it is applicable. But it is not the "ultimate" solution to shop problems.

Illustrative Example

Let us now consider a small scale example of making a decision on a production program and see how the method of representation and computation may be used. We will carry it through in some detail. Thereafter, we will show only how other types of problems may be placed in the necessary computational form, leaving to the reader the task of using the same computational algorithm to obtain a solution for them. The first example is deciding on the optimum mix of commodities to produce during one time period when there is an unlimited supply of all factors of production available, except machine capacity.

We assume only the following in this problem. The enterprise has two commodities which it can make, say machine screws of types 1 and 2. It can sell

as many as it makes at a constant price and the material which it buys for these screws is available in unlimited supply at a constant price. Also, labor is available in unlimited supply at a constant wage. We can say, therefore, that unit profit is constant and we take here to be the difference between variable costs (labor and material) and sales price. (We omit an interesting economic and accounting problem at this time on the correct method of handling overhead costs.) The enterprise also has an adequate supply of labor available which can operate any of its productive equipment at the same wage scale. Also, we assume that any operatives not required will find employment elsewhere. The firm has two machine tools used for making the screws. Each tool has a specified number of productive hours available during the period for which we wish to establish a program. We assume that the manager of the enterprise wishes to select the kind and number of screws to make which will give his company the maximum profit.

We now can begin to state this problem mathematically. Let us use the variable x_1 to indicate the number of screws of type 1 which we wish to produce in the optimum program, but which is as yet undetermined. Let x_2 be the same for screws of type 2. If, then, the unit profit of type 1 screws is 3 cents and the unit profit on type 2 screws is 4 cents, we will maximize profit $f(x)$ if we select x_1 and x_2 so as to maximize the sum:

1. $f(x) = 3x_1 + 4x_2$

Now, suppose, also, that each screw must be processed on each of the machine tools; machine 1 slots the heads, and machine 2 turns the threads. The amount of time in minutes required of each machine tool for processing one unit of each type of screw is:

	Machine Tool	
	Machine 1	Machine 2
Screw 1	2 Min.	5 Min.
Screw 2	3 Min.	2 Min.

These numbers are those typically determined by the time study department of a factory or office (they may be estimates, time studies, synthetic data, or other). For the period during which we are to develop the production program, assume that there are 3600 minutes of productive time available on each of the machine tools.

Now, we introduce the capacity restriction in the problem to assure that no machine is overloaded. Hence, we can state that the sum of the times required for processing selected amounts of both screws on machine 1 must be equal to or less than the amount of time available on machine 1. We can say the same for machine 2. These requirements can be stated mathematically as follows:

2. Machine 1: $2x_1 + 3x_2 \leq 3600.$
   Machine 2: $5x_1 + 2x_2 \leq 3600.$

Inasmuch as we are concerned in the real world only with "irreversible" processes, we cannot put in finished screws, run the machines in reverse, and

obtain the same amount of bar stock, electrical power, unused tools, etc., as those with which we began any process. Hence, we must add the further restriction that:

3. $x_1 \geqq 0$,
$x_2 \geqq 0$.

Now we may summarize the problem in mathematical form as follows:

2.1 Maximize:
$3x_1 + 4x_2$

subject to satisfying limitations on machine time capacity:

2.2 $2x_1 + 3x_2 \leqq 3600$
2.3 $5x_1 + 2x_2 \leqq 3600$

subject to not having any processes operating in reverse:

2.4 $x_1 \geqq 0, x_2 \geqq 0$.

A geometrical interpretation of the mathematics might be helpful in visualizing the problem. Let us construct a graph with two axes. Axis 1 represents the amount of screw 1 which is produced and axis 2 the amount of 2. Inasmuch as x_1 and x_2 are constrained to being equal to or greater than zero, we need only consider the positive orthant of this two dimensional graph. On this graph, let us plot the amount of both screw types which can be processed on each machine without exceeding the capacity of that machine. This will mean two "lines of capacity": one for each machine tool. On the graph which follows, line 1 refers to the upper limit of capacity of machine 1 and line 2 to machine 2. Line 1 is plotted, for example, by letting first x_1 be assumed equal to zero and then computing from 2.2 ($2x_1 + 3x_2 = 3600$) the largest value of x_2 which satisfies that inequality. In this case, the values are ($x_1 = 0$, $x_2 = 1800$).

Indeed, any other point on this line is represented by the intersection of the two lines representing its values in each of the two coordinates or axes. These other points may be determined for example by the table below wherein we choose first x_1 and then compute x_2. The result of plotting all possible points would be line 1. Because this is a "linear" inequality, we could have determined the line by any two points.

x_1	x_2
0	1200
1800	0
150	1100
300	1000
450	900
Etc.	Etc.

Technically, if we consider only integral numbers of screws, we would have a series of points rather than a continuous line.

Line 2, representing upper limit for capacity of: $5x_1 + 2x_2 = 3{,}600$

x_1	x_2
0	1800
720	0
20	1750
40	1700
60	1650
80	1600
100	1500
Etc.	Etc.

With these tables and the method of plotting, we now can illustrate geometrically the meaning of the two machine capacity limitations and the nonnegativity restrictions. The graph in this problem is shown in FIGURE A.

With this graphic portrayal, we see that we cannot process on machine tool 1 any combination of quantities of screws 1 and 2 which when plotted in the indicated manner falls above the line 1. We can produce less than the amount indicated by the line of capacity, however, by letting the machine stand idle some of the time. Hence, the "feasible" programs insofar as machine 1 is concerned would be all of those points (x_1, x_2) inside (nearer to the origin) and along the lines defining the triangle OBE. By similar reasoning, the "feasible" programs for machine 2 would be those points inside and along the lines of triangle OAD. But, since we can make finished screws only by using both machine tools and carrying out both operations, we must satisfy *both* machine tool capacity limitations. Hence, we are limited to programs which are feasible on both machine tools. The jointly feasible programs are those defined by the points inside the area common to both capacity limits, namely to the shaded polygon OACE.

Thus far, we have described only what programs the enterprise *can* carry out, considering the limitations on productive capacity. Our next task is to determine, under the given conditions, what program it *should* carry out in order to achieve its objective, i.e., maximize profit. To do this, we must introduce the profit maximizing form 2.1. Through this form we know that, for any given combination of quantities to produce, we can uniquely determine the profit which will be earned. For example, if a program specifies $x_1 = 150$ and $x_2 = 1100$ (taken from line 1 because it is the capacity restriction in this region), the profit is:

$$3 \times 150 + 4 \times 1100 = 4850$$

Hence, by the same method as before, we can plot as the third dimension on the graph in FIGURE A the profit from any productive program. The graph of the profit, considering the restriction imposed by machine 1, would be as shown in FIGURE B.

In FIGURE B, for the profit for any program as given by a point in the triangle OBE, there is a corresponding profit given in the triangle OFG, and the height of this point is the profit.

The graph of the profit, considering the restrictions imposed only by machine 2, would be as shown in FIGURE C.

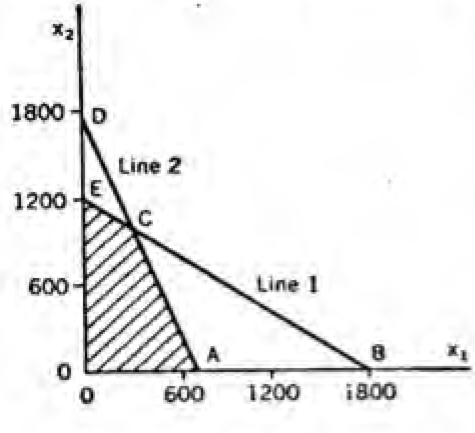

Figure A

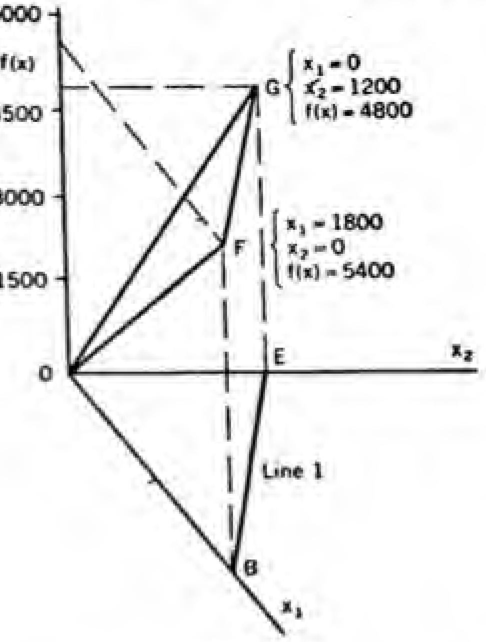

Figure B

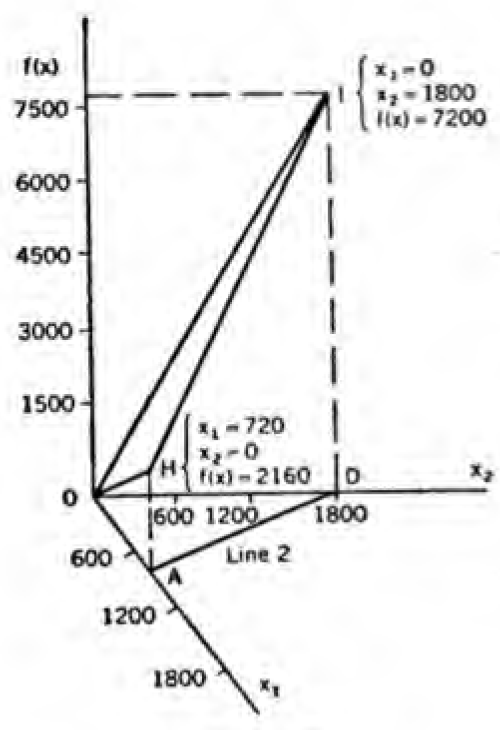

Figure C

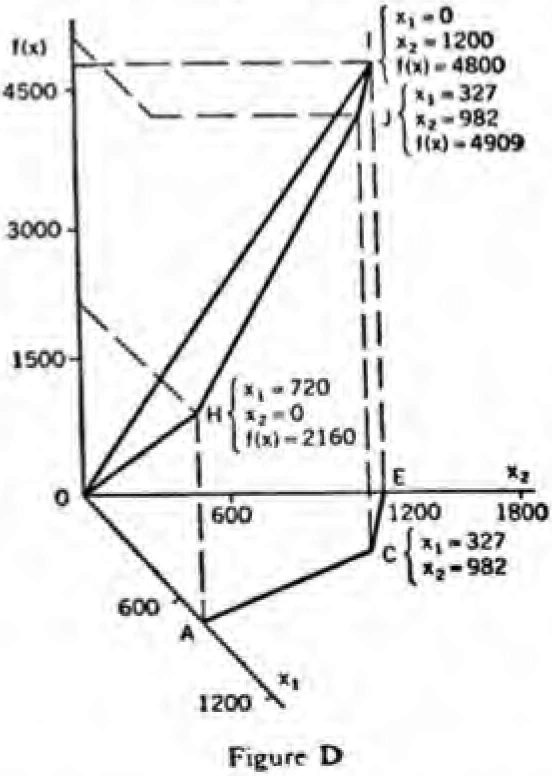

Figure D

It is recalled, however, that we are limited to a program which is feasible under both machine tools' capacity restrictions. Now by inspection of these graphs we can see several interesting properties. For example, in FIGURE B, we see that the "optimal" (most profitable) solution or program with respect to machine 1 is that which produces all possible of screw 1, whereas in FIGURE C, we see that the most profitable from the point of view of machine 2 is pro-

duction of all of screw 2. However, we can see also the obvious property that is profitable (under the assumptions of this problem) to produce all that is technologically feasible, whether that be screw 1 or screw 2. As we shall prove later on, but use heuristically now, this means that the optimal program will always be at some corner, such as point, A, C, or E in FIGURE A (or at 0 in case it is not profitable to produce at all). Hence, in this case, we need compare the profitability of only these three points as follows:

Point	x_1	x_2	P
A	720	0	2160
C	327	982	4909
E	0	1200	4800

In this particular problem, the most profitable program is Point C in FIGURE A or Point J in FIGURE D.

COMPUTATIONAL METHOD

One very important aspect of "model building" for managerial problems is that of computation. In the illustrative problem in the preceding section, the number of solutions which could have been optimum was so small that it was possible to enumerate them and choose from among them that one which is best. In the more general case, it is necessary to use other and more powerful methods of finding the optimum.

We can readily see in the illustrative problem that it would have been possible to use the theorem that as much as possible will be made, whatever that combination of screw 1 and screw 2 may be. In this case, it would have seemed possible to simply set up the two inequalities 2.2 and 2.3 as equations and solve for their intersection since in this problem that is where we found the optimum to be. However, in the general case this method will not necessarily give optimal solutions because:

1. There may be more unknowns than equations, and hence, no unique solution would be forced by this method.
2. The intersection of the lines of capacity would not necessarily be at one point. Further, by a simple change in profits between screw 1 and screw 2, it would have been possible to have the optimum solution or program lie at point E or A of FIGURE A.

The following computational technique, called the simplex method for programming, is largely due to the work of Dantzig. There are other methods, but for pedagogical reasons, we will not explore them all at this time. In any case, an adequate understanding of this method will be helpful in understanding other methods. Research is continuing, and improvements may be expected.

In order to explain the simplex method, refer to FIGURE D. It operates on a straightforward principle as follows: We begin at any point, such as O, A, B, or C; usually, however, at O because that is the only point at which we know reliably both where we are and that the program is technically feasible. At that point, we compute whether or not there is one or more other points that are both more profitable and technically feasible. We then proceed to that

next point toward which there is the greatest unit rate of profit. We compute what that point is, and then repeat the cycle until we find that there are no other points which are better. This point will be at least as good as or better than any other.

In order to illustrate this method, we now proceed with a step by step illustration of the computational method. The first step will be to find the point O. The second step will be to find point I. The third step will be to find point J. The final step will be to prove that no other point is better than J These steps are as follows:

STEP I

First, let us introduce the concept of "dummy" or fictitious screw types which we may think of as being produced, but which, in reality, represent "idle machine time." Screw type 3, then, is the idle time on machine 1, and screw type 4 is idle time on machine 2. Hence, any time not devoted to "real" production is conceived of as devoted to production of these dummy screws. The profit on the dummy screws is, of course, zero; and their unit rate of production is 1.

The mathematical problem becomes, then:

$$\begin{aligned} \text{Maximize: } & 3x_1 + 4x_2 + 0x_3 + 0x_4 \\ \text{Subject to: } & 2x_1 + 3x_2 + x_3 = 3600 \\ & 5x_1 + 2x_2 + x_4 = 3600 \\ & x_1, x_2, x_3, x_4 \geqq 0 \end{aligned}$$

As an aid to computation, we can express the problem in a slightly different format by using a table such as Table I below. This table should be read as interpreting "+" signs between the numbers in any row where separated by a single vertical line and an "=" sign where separated by a double vertical line. Also, the variable xi $(i = 1, 2, 3, 4)$ at the top of any column should be interpreted as multiplying each of the numbers in the column below it. The numbers in the column headed "C" are the productive capacity in minutes for the machine tool which is represented by the row in which the numbers appear.

TABLE 1

	x_1	x_2	x_3	x_4	C
Machine tool 1:	2	3	1	0	3600
Machine tool 2:	5	2	0	1	3600

The first step in this method is to select an assuredly feasible solution. This would be that solution for which $x_3 = 3600$ and $x_4 = 3600$, $x_1 = 0$, $x_2 = 0$. It would represent producing nothing and making no profit.

By a simple change in Table 1 we could denote this as the initial solution. We write it as:

TABLE 2

S
↓

S ↓	x_1	x_2	x_3	x_4	C
x_3	2	3	1	0	3600
x_4	5	2	0	1	3600

and think of the *solution of the problem at this step* as involving x_3 and x_4 as indicated under the column headed "S," and with values equal to the numbers in the column headed "C." We would have then the initial solution $x_3 = 3600$ and $x_4 = 3600$. This indeed would satisfy the "capacity" limitations; it would specify a program with 3600 minutes of idle time on machine 1 and 3600 minutes of idle time on machine 2.

This program is, of course, "feasible," but may not be "optimal." Hence, now we wish to take another step and get a "better" solution if such exists. We wish, also, to obtain such intermediate solutions as will take us via the shortest or most economical route to the optimal program. (Usually the method here will be the most economic.) To do this, let us rewrite Table 2 as follows:

TABLE 3

P →		3	4	0	0	C	T
↓	S ↓	x_1	x_2	x_3	x_4		
0	x_3	2	3	1	0	3600 =	0
0	x_4	5	2	0	1	3600 =	0
							0

Table 3 is the same as 2, except that a row and column "P" have been added at the top and the extreme left. Each number in that row or column is the unit profit of the screw which is indicated by the subscript of the x which is immediately below or to the right of it. The total profit from any intermediate or final solution is indicated under the column headed by "T" and is the sum of the entries in that column. These entries are obtained by multiplying corresponding entries under column P and column C. With the preceding, we have completed Step I and are ready to begin Step II.

Step II

In order to determine which screw will be most profitable to bring into the solution, do the following. Take the unit profit of each screw type not in the solution, x_1 and x_2, and subtract from it the profit on screws already in the solution which would be lost if one unit of that screw were brought into the solution. For example (1) take the unit profit on screw 1(=3). (2) compute the sum of unit profits which would be lost if one unit of screw 1 were produced, and (3) subtract the number determined in (2) from the number determined in (1).

Unit profit gained on screw 1		3
Profit lost on screw 3, unit 1	$2 \times 0 = 0$	
Profit lost on screw 4, unit 1	$5 \times 0 = 0$	
	0	0
Unit profit weight of screw 1:	$w_1 =$	3

Repeat the computation for the remaining screws not in the solution at this step.

The significance of these operations is as follows. If one unit of screw 1 is

brought into the solution, it will contribute its unit profit. But, simultaneously, it will take productive capacity away from the screws that are already in the current solution. Since producing one unit of screw 1 will take 2 minutes of time on machine 1, it will take away capacity for 2 units of screw 3; similarly, it will take away capacity for 5 units of screw 4. Hence, in order to determine whether or not it is profitable to bring any one screw into the solution, we must take its unit profit and subtract from that the total profit which would be lost on the other screws which its production would preclude.

This operation thus computes the *net unit profit* which would be obtained by bringing into the current solution one unit of each of the screws not already in the solution. The screw with the largest profit weight w is the one which should be brought next into the solution. The profit-weighting function for each screw as computed by this method is written under its corresponding column as in Table 4.

TABLE 4

P →	S					C	T
		3	4	0	0		
↓	↓	x_1	x_2	x_3	x_4		
0	x_3	2	3	1	0	3600 =	0
0	x_4	5	2	0	1	3600 =	0
w →		3	4				0

In this case, the screw with the larger net unit profit is screw 2, with a value of 4. This tells us, therefore, that we want to go along the x_2 axis in the graph in FIGURE D from point 0 to point I.

In the computational method here, we find this point as follows: Compute the amount of screw 2 that we can bring into the solution by dividing each entry in the column under x_2 into the capacity of the machine tool corresponding to the row in which the entry is located. Specifically, in the row opposite x_3 we divide

$$3600/3 = 1200$$

and in the row opposite x_4 we divide

$$3600/2 = 1800.$$

This computes the number of units of screw 2 respectively if machine 1 and machine 2 were devoted full time to producing screw 2. It is simply dividing the productive hours available on each machine by the production standard for one unit of screw 2 on that machine.

It is recalled from the graph in FIGURE A that we are limited to solutions within the shaded area. This area delimits by the combined capacity for both machines. Obviously, therefore, we must choose an *amount* of screw 2 to produce which does not exceed that capacity Hence, in order that we may include an amount of screw 2 in the solution which is up to, but does not exceed, the lower of the two capacities, we must take the lesser of the numbers so determined, i.e., 1200. The results of this computation are summarized in Table 5

TABLE 5

P →		3	4	0	0	C	A (amount)
↓	S	x_1	x_2	x_3	x_4		
0	x_3	2	3	1	0	3600	3600/3 = *1200*
0	x_4	5	2	0	1	3600	3600/2 = 1800
w ⟶			3	*4*			

We must now account for the changes which this has made in the shop load. This we do as follows in Table 6 with a tabulation of the values at the beginning of this step, the changes, and the values at the end of the step.

TABLE 6

	x_1	x_2	x_3	x_4
Solution of the initial step . . .	0	0	3600	3600
The changes to be made in the initial solution	0	+ 1200	−(1200 x3) = −3600	−(1200 x2) = −2400
New or current step's solution	0	1200	0	1200

In this we began with the "initial solution" $x_1 = 0$, $x_2 = 0$, $x_3 = 3600$, and $x_4 = 3600$. Next, we computed the changes involved from changing the initial solution by adding 1200 of screw 2. Since we are adding 1200 of screw 2, we enter it directly in its appropriate position in the change row. Then we multiply the 1200 by each of the entries in the column under x_2 in Table 5. Each number so computed is entered in the appropriate space in the change row. That is, the number 3600, which was computed by multiplying 1200 by the 3 under the x_2 column in Table 5 and at the intersection with the x_3 row is entered in the x_3 space of the "change" row. We do the same for the number 2400 which was computed by multiplying the 2 under the x_2 column at the intersection with the x_4 row, but enter it in the x_4 space of the change row. Each such product, for example 1200 x 3 = 3600, determines the amount of screw 3 or 4 (idle time) excluded from the new solution. It is recalled that this amount of screw 3 is excluded from the new solution because for every one unit of screw 2 we produce, we eliminate 3 units of screw 3. Similarly, 1200 x 2 = 2400 units of screw 4 are excluded. The new current solution is obtained by adding or subtracting, as appropriate, the numbers in the change row from the previous solution row. The balance appears in the new current solution row. The profit at this step in the solution is, of course, the number of units produced times the unit profit: 4 x 1200 = 4800.

We must get ready for proceeding from point I to point J in order to improve further the profitability of the solution. Where previously we had production of 3600 of screw 3 and 3600 of screw 4, we now have 1200 of screw 2 and 1200 of screw 4. The composition of the production program at the initial solution, it is recalled, was indicated by the x_3 and x_4 located in the left hand column headed "S." Now, in the next computational table, x_3 will be removed from the solution column because x_3 has been replaced by x_2 in the solution at this step.

From Table 2 we can state that if we produce one unit of screw 1, we will

exclude capacity to make 2 units of screw 3 on machine 1, plus capacity to make 5 units of screw 4 on machine 2. Since screw 3 is not made on machine 2 and screw 4 is not made on machine 1, we can write $x_1 = 2x_3 + 5x_4$.

Similarly, from this table we can write for each other screw

$$\begin{aligned} x_2 &= 3x_3 + 2x_4 \\ x_3 &= x_3 + 0x_4 \\ x_4 &= 0x_3 + x_4 \end{aligned}$$

Now, if screw 2 is brought into the solution column at this step in place of screw 3, the bare table would be

	x_1	x_2	x_3	x_4	C
x_2	....	....	....	....	1200
x_4	....	....	....	....	1200

In order to carry out the next step in the computations we want to fill out the entries in the table. To do this we want to find similar equations for the x's in the top row, but now in terms of the x's which are in the solution column along the left side. To do this, we solve for x_1, x_2, x_3, and x_4 in terms of x_2 and x_4 (instead of x_3 and x_4, as they were in Table 6). This step is carried out as follows:

Take the equations from Table 2:

$$x_1 = 2x_3 + 5x_4 \ ^{*}$$

$$x_2 = 3x_3 + 2x_4$$

and solve for x_1 and x_3 in terms of x_2 and x_4, as follows:

$$x_3 = \frac{x_2}{3} - {}^{2}/_{3}\, x_4$$

$$x_1 = 2\left(\frac{x_2}{3} - {}^{2}/_{3}\, x_4\right) + 5x_4$$

$$x_1 = {}^{2}/_{3}\, x_2 + {}^{11}/_{3}\, x_4$$

These equations have the same significance as those derived from Table 2, and, hence, we can enter the coefficients in them into Table 7 as follows:

TABLE 7

P →		3	4	0	0	C
↓	S ↓	x_1	x_2	x_3	x_4	
4	x_2	2/3	1	1/3	0	1200
0	x_4	-11/3	0	−2/3	1	1200

* Those familiar with linear algebra and matrix theory will recognize these equations as equivalent to the following vector equation:

$$x_1 \binom{1}{0} + x_2 \binom{0}{1} = x_3 \binom{2}{5} + x_4 \binom{3}{2}$$

STEP III

This step is identical to the preceding step and is summarized as follows in Table 8.

TABLE 8

P ⟶		3	4	0	0	C	A
↓	S ↓	x_1	x_2	x_3	x_4		
4	x_2	2/3	1	1/3	0	1200 + 1800	
0	x_4	11/3	0	−2/3	1	1200 + 327	
w ⟶		$3 - (8/3 + 11/3 \cdot 0) = 1/3$		$0 - (4/3 - 2/3 \cdot 0) = -4/3$			

	x_1	x_2	x_3	x_4
Previous solution	0	1200	0	1200
		−2/3x327	0	−(11/3x327)
Change	+327	= −218	0	= −1200
New solution	327	982	0	0

STEP IV

Inasmuch as we solved this problem graphically, we know already that we have achieved the optimal solution. However, in the more general case, we will not know this without a final step which will tell us that the solution at that step was optimal. This step, a repetition of earlier steps, is as follows:

$$\text{Use } x_1 = 2/3\, x_3 + 11/3\, x_4$$
$$x_2 = 1/3\, x_3 - 2/3\, x_4$$

to determine x_3 and x_4 in terms of x_1 and x_2

$$x_4 = 3/11\, x_1 - 2/11\, x_2$$
$$x_3 = 2/11\, x_1 + 5/11\, x_2$$

P ⟶		3	4	0	0	C
↓	S ↓	x_1	x_2	x_3	x_4	
3	x_1	1	0	−2/11	3/11	327
4	x_2	0	1	5/11	−2/11	982
w ⟶				0 − 14/11 = 14/11	0 − 1/11 = 1/11	

Since there is no screw with a positive value of w at this step, there is no way to change the solution and achieve an improvement in profitability. Hence, this solution or program is optional. There is no better way, regardless of whether or not the method by which the program was developed is understood by the salesman who sells screw 1 or the salesman who sells screw 2. If there is any change in this production program, it will decrease profits. The only possible change that could improve profitability would be one that is based on some basic error, such as incorrect profit accounting in setting up the

problem originally. We are, indeed, at the highest point on the profit plane in this problem.

This type of representation and solution is, indeed, objective and scientific —once the basic facts have been agreed upon by the interested parties. In this case it has determined the "required quantity" in relation to an objective criterion, profit.

GENERALIZATION

We now wish to extend this method in several directions. We will do this only by indicating how the various conditions can be incorporated into the preceding computational technique. We will not give mathematical proofs, but concern ourselves with recognizing real-world problems and placing them in such form that we can solve them by methods already proven by mathematicians.

(a) Programming over-time

The basic model presented in the introduction will handle this problem adequately simply by including the superscript time periods. There are, however, certain additional conditions which it may be necessary to observe. For example, it is noted that the model implies computing the load by machine tool (or machine tool type) by period. If there is an interdependence between production in one period and production in another, this must be included as a restriction. For example, it may be necessary to use the output of one period as the input of the next; a fixed amount of raw material may be available for allocated use over several periods, etc. Suitable restricting equations or inequalities can be developed to handle these.

(b) Material allocation

If we have any raw or semi-finished materials in stock which can be used in two or more different end items, we have potentially a problem in determining how the material will be allocated. This problem can be handled easily by a set of restricting inequalities in which the coefficients b_{ik} indicate the amount of raw material k required in the production of one unit of item i, etc., for C_k.

(c) Alternative production methods

The most profitable program is not necessarily the one which uses only the "cheapest" method for every commodity being produced. Such program may entail, rather, use of alternative, and more costly, methods. Failure to use alternatives may result unnecessarily in delayed deliveries. loss of sales, loss of goodwill, etc.

This problem can be handled by including profit estimates in the objective function which reflects both the loss of revenue from delayed deliveries and the extra cost of using the alternative methods.

Accountants have failed to recognize this concept in their reporting and analysis methods. Their result often is to cause operating personnel to conceal or restrict their use of alternative methods, when, indeed, such would be the most profitable thing to do.

If the problem involves questions of loss of goodwill, it is necessary to obtain numerical values for this loss. This can be done by using estimates obtained by "forcing" the general manager responsible for the firm to reveal the amounts he would "pay" for avoiding specified late deliveries. The values so obtained then can be used directly in the objective function.

(d) Inventory costs

"A thin stream of swiftly flowing inventory with a high level of machine utilization" is one qualitative description of the optimal in-process inventory policy. It can be computed numerically with the methods discussed here. It is necessary only to attach appropriate costs to material in storage, to include appropriate restrictions on amount of material which can be stored due to financial limitations, space limitations, or other.

(e) Economic lot size

It has generally been recognized that the amount to produce as determined by economic lot size is not necessarily the most "economic." This fact is now explainable because these formula consider lot size only in relation to the profitability of that item alone, rather than of all items simultaneously. However, the linearity assumption of the model presented here is unrealistic in a problem in which there are strong non-linear relations in unit cost of production as a function of quantity.

The two alternative methods for determining quantity to be produced in a lot can be combined as follows. Compute the economic lot size and a range about that size over which unit cost is equal to or less than, say, 110% of minimum. Then, in the computations in the method here, restrict the amount of each commodity to a value which lies within that range.

(f) Fixed sales requirements

If the minimum amount of production of any one or more items is predetermined (that is, they simply "must" be produced), it facilitates computation to change variables so as to account for this requirement and eliminate this restriction from the computational problem. For example, say the amount of

$$x^t_1 \geqq d^t_1 \quad , \quad d^t_1 \geqq 0$$

Then we could write

$$x^t_1 - y^t_1 + d^t_1 \quad , \quad y_1 \geqq 0$$

Substitute the variable $(y^t_1 + d^t_1)$ for x_1 in the objective function and the restricting inequalities and proceed as before. This effectively adds at least $d^t_1 \times a^t_1$ to the profit and subtracts $d^t_1 \times b_{1k}$ productive hours from the available capacity of the k*th* machine tool during the t*th* period.

This method may bring to light many incongruous situations wherein the "must" production is greater than the available capacity. The existence of this condition would be made apparent by the "must" production violating the capacity restrictions.

(g) Cost minimization

If we have a problem in which the final bill of items is determined, the objective function becomes cost minimization. In this case, we would invert the computational procedure by taking as given the quantity of each item to be produced and then selecting the combination of equipment and methods which will produce these with the minimum cost.

(h) Profit accounting and marginal costs

Generally speaking, accountants are not trained in mathematics beyond the principles of arithmetic and the algebraic methods of interest and annuities. Indeed, however, they are responsible for evaluating performance of operating personnel in several regards, for data analysis in managerial decision making, and for many other important functions.

Vatter already has pointed out some of the proper methods of data analysis for managerial accounting. Additional ones become available when one views the managerial decision through a mathematical model.

The standard costing as practiced is usually based on fallacious notions. It penalizes often where penalties are not due; it evaluates against an incorrect concept.

Variations from standard cost have no unfavorable meaning unless they are due to an act or event which reduces profit rather than just increases cost. If an alternate machine tool, substitute operator, substitute material, or other is used in place of that on which the standard was determined, it may have been quite appropriate. The only method of so determining would be to reconstruct the situation as it existed at the time the decision to use the alternate was made and then make a computation of the type indicated in this paper to determine if the best decision was made. But, this best decision probably would be achieved only if this type of computation were made.

The consequences of this philosophy are, indeed, significant. It could lead to the concept of "profit accounting" instead of "cost accounting," such that all levels of executive decisions would be evaluated against profit rather than cost. This would tend to give operating personnel objectives more consistent with the objectives of their firm. Of course, before this could be done, it would be necessary to adopt considerably revised analysis and reporting procedures in lieu of present cost procedures. This would depend, of course, upon adequate training and facility in methods such as those discussed here.

Depreciation and overhead were not included in this formulation. The reason is that, generally, these are sunk or fixed costs. The objective of the firm is to maximize revenue over expenditures at each point in time, and hope that in the long run this will assure its existence into perpetuity by recovering sunk costs and making replacements possible. If these sunk costs are included in the determination of the profit used in the model, it would indicate only whether or not at that particular time they are being recovered by prices and production. If they are used in the computations for determining whether or not an item should be produced, this would be incorrect.

A preferred profit accounting approach should be to consider only variable and semi-fixed costs as charged against revenue in determining what and how many commodities should be produced. The semi-fixed costs can be intro-

duced easily by penalties charged for using equipment or facilities above given levels of activity. Indeed, it is possible to include in the maximizing function both the prices and the variable and semi-fixed costs. However, it is usually easier to compute the net profit before commencing the programming computations. (We avoid here attempting to define "profit" beyond "excess of current income over current outlays for variable and semi-fixed costs." Persons having a different word for this definition may insert theirs at every point where "profit" is used in this paper.)

PART III

THE BUSINESS AS PART OF THE NATIONAL PLANT

INTRODUCTION

THE READER has certainly not failed to recognize the general assumption underlying the discussion in Part I and Part II, namely the assumption that the product is being sold.

If this were not the case, there would be little use in devising ways of visualizing the business or controlling its expenses.

But it is time now to consider if and under what conditions such an assumption is justified. This is why Part III of this study on the economics of industrial management will be devoted to some aspects of the problem of integration of the individual plant within the "national plant" as a whole.

It is impossible indeed to consume what is not produced and distributed to the proper place at the proper time, for the proper price. Neither is there any use, nor any economic possibility, in producing what cannot be ultimately consumed.

Production, distribution, consumption are *not* three distinct eco-

nomic activities but rather three phases of what could be considered the general economic flow of the national plant as a whole. Without the two other phases any one of the three is meaningless. Even more so, since any one individual within the national plant seldom acts in one capacity only. A farmer is a producer of food and also a consumer of manufactured products at the same time. A plant worker is a producer and also a consumer of food and of manufactured products. A dealer distributes the goods, but he consumes them too.

Maladjustments and conflicts may well appear between such groups, but they are *not* the unavoidable consequences of any fundamental opposition—only the accidental result of a lack of integration.

Maximum efficiency calls for *coordination* of efforts, which in turn means certain limitation of individual action.

The story is told of an old tailor who lived in a small town in New England. This was in the early days of the nineteenth century. The tailor had just finished a custom-made suit of clothes, which was made of expensive French silk, imported from Lyon.

The tailor's youngest helper went to deliver the suit, but in the evening he brought it back. The sleeves were too long—one inch. The customer wanted the suit ready for the following day, with the sleeves duly shortened.

By that time, as it was getting late, the tailor's two helpers were leaving. The younger one—who had just brought the suit back—was greatly excited and in a hurry as he was to be married the very next day and, indeed, was very much in love. As soon as he had given the customer's message, he disappeared. As for the older helper, it was his rule to leave early, since he had a long way to go. Besides, such alterations were none of his business as he was the cutter. The younger one did that kind of work.

After both had left, the old tailor, anxious to please his customer, who was a prominent man in the town, did the work himself although as a rule he no longer touched the needle for fear of straining his eyes.

The young boy was worried, however, because his wedding plans were interfering with his duty. Perhaps he saw there a bad omen, or was it that the tailor was a good boss and that he wanted to *cooperate*?

Anyway, the next morning, before daylight, he went to the shop and shortened the sleeves another inch, returning home quickly, in time for his wedding.

The other helper was equally fond of the boss and he also got up early, though not quite as early as his younger associate. He also

wanted to *cooperate*, and arrived at the shop after the younger helper's departure—but before the master's arrival. And he took another inch off the sleeves.

When the tailor arrived, the nice and expensive suit of clothes, of French silk, directly imported from Lyon, was damaged beyond repair—which somehow illustrates the difference between *cooperation* and *coordination*.

In all their enterprises, men strive for efficiency and at the same time remain jealous of their independence. Thus a conflict arises, which, according to the times and circumstances, is solved one way or the other.

It is a striking fact that every possible effort has been made during the last twenty years to develop to its maximum the coordination of efforts within the individual plant while so little has been done to develop the integration within the national plant. Scientific management would avoid the repetition of a mishap, as the one just related in the tailor shop, because it has organized the will to *cooperate* within the framework of *coordination*.

But, up to now, the principles of scientific management have not been adopted in the operation of the national plant as a whole on an adequate scale.

There are many reasons for this difference in treatment of the two problems in spite of their obvious similarity. One of the reasons often given is that the individual plants are submitted to a single authority, while the national plant is not.

The validity of this reasoning seems even more convincing if one considers that in some other countries the integration of the national plant has been realized by the substitution of a central authority for the individual ones. But this way of reasoning is a mistake, all the same. It assumes that integration is only possible through authoritarian methods and not through a free and self-imposed discipline—which assumption is in open contradiction with the facts of everyday life.

Individual liberty and personality do *not* necessarily suppose a total absence of rules, a limitless freedom of action to express themselves, nor does the adoption of a common goal and of a common timing of efforts necessarily infringe upon them. What really counts is the conditions in which the coordination of efforts is organized.

The members of a very distinguished club impose upon themselves countless restrictions as to their language, clothing, attitude toward the other members, etc. Yet they feel—and indeed, they are—infinitely

more free than the prisoners of a concentration camp who ignore such self-imposed rules.

Scientific management of the individual plant was, at first, regarded by quite a few as an unbearable regimentation of the individual. It is today recognized for what it is: the scientific integration of efforts by a freely accepted coordination of activity.

Another reason that has prevented the integration of the national plant on a more substantial scale is also, indeed, that such integration was just not possible until very recently.

The first step, before integrating the whole, was obviously to integrate the component parts—and scientific management is comparatively young, not even universally practiced.

Also, there is a deep-rooted belief which works against the trend toward integration, namely, the belief in scarcity.

For ages, that is, from the dawn of civilization and up to the very last decades, the capacity to produce was so obviously below the ability to consume that it was utterly useless to worry about any kind of equilibrium.

A man who earns less than enough to buy his daily food does not bother very much with establishing a well-balanced annual budget of income and expense.

For ages, the only problem was to produce more and more. There was an apparently inexhaustible reservoir of ability to consume. But the ability to consume cannot be measured only in terms of needs; it must also be measured in terms of ability to consume under such conditions as to make production economically possible.

The economic crises of the 1930's show that the problem is a very actual one.

The periodical world conflicts and the international insecurity of the 1950's, by providing abnormal consumption channels, may make less apparent the potentialities of modern production.

At the same time, however, such conflicts provide an experimental demonstration of the impressive discrepancy between the capacity to produce and the ability to consume within the national plant when a proper degree of integration is attained. There can hardly be a more convincing demonstration than the sudden increase of production in the United States in the first years of World War II, while the standard of living of the population, by and large, was actually safeguarded—especially if one considers that, at that time, a very substantial part of the population, indeed the most active part of the population, was actually waging war, i.e., consuming restlessly and producing nothing,

As a matter of fact, the economic stability attained during the war has been so impressive and the fear of the return of such a depression as that of the 1930's so common that after World War II various proposals have been made by influential industrial groups for improving the economic integration of the national plant.*

Such an integration is, indeed, existing today to a very substantial extent. The public utilities are an example of groups of industries integrated under the guidance of various authorities, such as the public utilities commissions. Trade associations, in as much as they foster a better organization of production, distribution and consumption in a given group of industries are also factors of integration. Standardization of production, which is at the same time a standardization of consumption, is another factor of integration. The Federal Reserve System is an integration, to a certain degree, of the banking business.

Federal price support for farm products has been a form of integration of agricultural production. The National Defense requirements in recent years have been the reason for direct and indirect subsidies and help granted to certain industries for the stockpiling of certain types of raw materials, and have also been the main cause of a very considerable increase in Federal purchases of goods and services, all of which has resulted in an indirect integration of industrial production.

Given the degree of integration actually attained within the national plant, what should be the managerial economic policy of the business so as to be best adapted to today's conditions?

Furthermore, what are the trends toward a change in these conditions?

These are the problems which will now be explored.

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* See Chapter XV.

XIV

THE DOLLAR AS AN ECONOMIC YARDSTICK

JUST AS STEEL is weighed by the ton, wheat is measured in bushels, and butter is delivered by the pound, so business performances—income, expense, asset values, to mention a few—are estimated in dollars. The businessman measures the extent of his success or of his failure in terms of dollars. It is in terms of dollars that he makes his plans. The dollar is his economic yardstick.

Usually yardsticks are essentially characterized by their fixity. The size of the bushel in 1939 was the same as it is today. No one speaks of a ton 1936, of a ton 1957, which would imply that the ton 1957 is not the same as the ton 1936 (although one must be careful to specify the short ton or the long ton). Transactions and accounting would become much more difficult if such yardsticks as the ton, the bushel, etc., would vary. Yet the economic yardstick, the dollar, is a variable one. Today we speak of the 1939 dollar and the 1957 dollar—implying by this that the dollar as an economic yardstick has changed so sub-

stantially between 1939 and 1957, that the 1939 dollar and the 1957 dollar are two different units of measurement. This implication is unfortunately correct. Disturbing as such a fact may be, it is a fact and it is of the utmost importance to the businessman to recognize it as such. In as much as the economic yardstick, the dollar, does vary, the businessman must be aware of its variations and be able to correct their effects as much as possible. It is not always clear to the businessman that when prices change, this phenomenon may be due to one of two causes: either a fluctuation resulting from usual business market operations or a variation in the dimensions of the yardstick (the dollar) used to measure business activity.* Two examples may assist in showing the relation between money and goods. In the first place, let us take the case of a manufacturer of any commodity such as automobiles. In a given year, say 1920, if he produces 100,000 automobiles at a total expense, for materials, wages, interest, dividends and all other charges, of 100 million dollars, the automobiles are said to cost $1,000 each. Let us assume that instead of using dollars, the manufacturer were to use certificates of ownership in the goods produced and that all wages, salaries, materials, interest, dividends, etc. were paid by distributing these certificates of ownership instead of dollars. All those who supplied materials, labor, and other services would then hold certificates of ownership in the 100,000 automobiles produced instead of having money in the bank. Let us assume hat a standard certificate be established as equal to one automobile. The entire year's production would therefore be represented by 100,000 standard certificates, each one of which is equal to one automobile so that the owner of such a certificate could go to the warehouse and claim one automobile. It may be written then that;

$$100{,}000 \text{ standard certificates} = 100{,}000 \text{ automobiles}$$

or

$$1 \text{ standard certificate} = 1 \text{ automobile}$$

This would give a value of $1,000 to each certificate of ownership in 1920. Let us assume that in another year, say 1930, the manufacturer improves his methods of manufacture such that he produces 120,000 automobiles with the same labor force and the same interest charges, but more materials cost, so that his total expenses are 108 million dollars. The cost of one automobile will then be $900. If now instead of using money to pay all expenses the manufacturer would use cer-

* See note, page 375.

tificates of ownership, as he did in 1920, on the basis that one standard certificate shall be equal to one automobile, then he will distribute 120,000 certificates in payment of all expenses, and each standard certificate will be a claim to one automobile. But the reader will object at once to the use of a standard certificate the one year worth $1,000 and a standard certificate the other year worth $900. Such use of a *standard* does not make sense, he will say; the two certificates should be of the same value. But are they not? They are each worth one automobile, of the same kind in every respect. Yes, the reader will say, but they are not of the same value in dollars, for the certificate issued the one year, 1920, was worth $1,000 and the one issued the other year, 1930, was worth $900.

But let us not forget that the value of the certificate is, by definition, "one automobile" (of a specific type, size, and quality). The decrease in the value of the certificate over the years, as expressed in dollars, simply shows that the price of each automobile has gone down. This is a case of price fluctuation. In our example the fluctuation is due to technical progress which reduced the cost of production. The second example used to show the relation between money and goods will now illustrate what happens in a fundamentally different situation.

We will consider the case of issuing certificates or claims to goods not paralleled by the production of goods, which the attentive reader will realize is bringing us nearer to an understanding of what is happening in our economy. For instance, when one borrows money at the bank, he receives a credit or deposit in his account against which he can issue checks in purchasing goods and services. By creating such credits or deposits, the banker creates claims to goods in excess of those already issued in the form of wages, salaries, interest, dividends, and other charges on production when the goods were produced. This process causes *variations* in the value of the dollar. Whenever the number of claims to goods or certificates of ownership of goods, which is what the dollar is, become greater than the goods to be claimed, then the value of the claims to goods, the dollar, becomes less; the dimension of the yardstick is changed. Let us consider the following situation by way of illustration. Suppose the automobile warehouse of the previous example caught fire and one-half the autos were destroyed. Instead of honoring the first 50,000 certificates presented and delivering the 50,000 remaining cars to their holders, leaving the other 50,000 certificates worthless, it would be provided that since half the cars are destroyed, each of the remaining cars is

now worth two certificates. This means that the value of each certificate has been reduced to half the value it had when issued. If you think in terms of dollars, you may argue that the claims to goods, the certificates issued, being in excess of the goods they represent, the value of the claim to goods, the certificate, has gone down. Thinking in these latter terms will help us to understand a very important phenomenon of our wartime economy, which has much significance to the businessman, be he manufacturer or merchant. During the war we produced great quantities of goods and at the same time issued corresponding certificates of ownership of such goods. The majority of the goods produced in the period 1940 to 1945 were military goods, most of which were destroyed. But after the war the certificates of ownership of such goods were still in existence and were being used to buy automobiles, washing machines, houses, and many other commodities. These certificates also increased in amount in time because of accumulated interest charges and the operation of our banking credit system subsequently referred to. So the result was that the unit of value, the dollar, in terms of which these certificates were written, has declined materially. The 1948 dollar had substantially less value than the 1939 dollar.

The *variation* * in the value of the dollar is not to be confused with the *fluctuation* † in prices due to the activities of the market place. Many businessmen are much more interested in the *fluctuations* in prices which they carefully follow day by day than in the *variation* in the value of money. But there are a number of practical reasons why the businessman should be concerned about the variation in the value of the dollar, especially when it tends to stabilize at lower levels, as is indicated at the present time.

This chapter is mainly concerned with a study of today's conditions in the United States. There have been other times, in America and in other countries, in which changes in the value of money have taken place. Some of them will be briefly referred to in this chapter. But it should be noted that we are facing today an entirely different and new situation which is not comparable to former and apparently similar conditions affecting the value of the dollar. It is true, for instance, that there were fluctuations in prices in the early twenties that are reminiscent of the ones we are presently witnessing. But the very substantial variation in the value of money experienced in the

* Variation is "change in condition, character, degree, etc."
† Fluctuation is "continual change from one course, position, condition, etc., to another."

recent past is something new in modern American history. It is the direct result of the great monetary inflation that followed World War II. It has been substantially increased by the credit inflation experienced after 1950.

What is inflation?

In a statement before the Joint Committee on the Economic Report, Special Session of Congress, November 25, 1947,* Marriner S. Eccles, the then Chairman of the Board of Governors of the Federal Reserve System, defined inflation as,

". . . the condition which exists when effective demand exceeds the over-all supply of goods and services."

This definition indicates that there are two possible causes of inflation, which may, of course, be coexisting:

1. Inflation may result from a decline in the supply of goods and services, but with a steady demand.
2. Inflation may result from an increase in effective demand, but with a steady supply of goods and services.

During the war, however, while the supply of goods and services available to civilians was not sufficient to satisfy the demand, government controls of prices prevented inflation.

After the termination of the government controls of prices, a rapid industrial reconversion enabled production of civilian goods to reestablish itself. The supply of goods and services in the United States was very soon equal to or even larger than before the war, even if one takes into account the increase of population and the backlog of unsatisfied needs.

This then suggests that the inflation that has been experienced in the United States during the decade following World War II was *not* due to a relative decline in the supply of goods and services, but *was* due to a relative increase in effective demand.†

"Effective demand" is the subject of the next chapter. It will be shown how effective demand can best be measured for a country by an estimate of the total population and of the inhabitants' purchasing power.

The purchasing power is influenced by many factors, such as economic activity, speed of circulation of the money, saving habits, dis-

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* Reprinted in the *Federal Reserve Bulletin*, December, 1947.

† For an extensive study of the problem of inflation throughout the world, see A. J. Brown, *The Great Inflation. 1939-1951*, Oxford University Press 1955

tribution of income, tax laws, etc. It is also influenced and greatly so by the supply of money. When this supply of money increases at a rapid rate, the result is inflation which is the subject of the present chapter.

In recent years inflation has been a well recognized and very influential factor of economic development. Immediately after World War II, inflation was exclusively monetary; in the early 1950's, in this country, a credit inflation began to be felt.

There is a fundamental difference between the two. The former has an irreversible character. In some nations it has sometimes gone out of control and resulted in financial bankruptcy and change in money, but there is no historical precedent of any monetary inflation that has ever been reabsorbed. The opposite is true for credit inflation. It has a long-range rather than a short-range character and, for this reason, its impact should be considered as a *variation* rather than as a *fluctuation* in accordance with the definitions previously given. At the same time, credit inflation is definitely a reversible process. In fact a brutal reversal may be the origin of such serious economic disturbances as were experienced in the 1930's.

Today the impact of both monetary and credit inflation is being felt, and they must both be given full attention at this time.

I. MONETARY INFLATION

An individual or a business that spends more than it earns will, in the final analysis, go bankrupt. A national government generally does not. A government will face excessive expenses by artificially increasing its supply of money by "inflating" it.

The process of inflation as a way for a nation to face otherwise unbearable expenses is as old as economic civilization itself. Solon, in Athens, during the sixth century B.C., was responsible for what is probably the first recorded inflation of money. Later on, it was through inflation that the Roman magistrates financed the Punic Wars. Further examples occur in almost every century. In the Middle Ages, tampering with the money was one of the most generally adopted means of financing used by many European kings and feudal lords. The French Revolution proclaimed new principles of freedom in Europe but, financially, it followed the old routine of inflation by printing millions and millions of soon worthless *assignats*. The financial history of the European and Asiatic governments during the first half of the twentieth century is too well known to need comment in this respect.

However, while the process of inflation is as old as the use of money,

the technique of inflation has changed considerably. In times past, the technique followed by governments was simply to reduce the size of the coins. For obvious psychological reasons, they soon learned to practice a more refined technique: the coin would not change in size; the proportion of precious metal (gold or silver) to the other less expensive metals would decrease. Such a change is not generally noticed by the public.

But with the general use of paper currency, inflation became a simple technique of printing inexpensive banknotes in greater number and value than usual. This was essentially the way inflation developed in most countries during and after the wars. (Table XLV.)

To a certain extent, this practice was also followed in the United States to help finance World War II. The circulation of currency in the U.S. increased from 6.4 billions of dollars in 1939 to 26.7 billions of dollars in 1946.

TABLE XLV

MONETARY INFLATION IN VARIOUS COUNTRIES DURING WORLD WAR II

	FRANCE Billions of Francs		UNITED KINGDOM Billions of Pounds Sterling		AUSTRALIA Millions of Australian Pounds		CANADA Millions of Canadian Dollars		UNITED STATES Billions of Dollars	
	1939	1946	1939	1946	1939	1946	1939	1946	1939	1946
Currency	151	722	.50	1.38	54	211	281	1,095	6.4	26.7
Deposit money	59	704	1.25	3.82	149	492	2,662	5,980	29.8	83.0
Total money supply	210	1,426	1.75	5.20	204	703	2,944	7,075	36.2	109.7

Source: *International Financial Stat'stics*, Washington, D.C., January, 1948.

But, as is well known, the total ·upply of money in a modern country is a complex total of currency (essentially paper currency) and bank credits or *bank deposits.**

In some countries, paper and metal currency is still the most generally used form of money. In other countries, on the contrary, the currency is largely in the form of bank deposits. Table XLVI shows how the United States compared in this respect with another country, France, for instance, in 1939.

* For an extensive study of the subject, see George N. Halm, *Economics of Money and Banking*, Richard D. Irwin, Inc., 1956.

TABLE XLVI

MONEY SUPPLY IN THE UNITED STATES AND IN FRANCE (1939)

	France	U.S.	France	U.S.
	(Billions of Francs)	(Billions of Dollars)	Percent of Total Money Supply	
Currency	151	6.4	71.9	17.6
Deposit money	59	29.8	28.1	82.4
Total money supply	210	36.2	100	100

Source: *International Financial Statistics*, Washington, D.C., January, 1948.

Such figures show how fundamentally different the situations were in the two nations. In France, in 1939, almost three fourths of the total money supply was in currency. In the United States, however, in 1939, currency represented less than one fifth of the total money supply.

Inflation in the United States had to follow a process adapted to the financial structure of the country. The mere printing of additional currency would obviously not have served the purpose even if it had been technically and legally desirable and permissible.

In fact, the technique followed was a very refined utilization of the flexibility of this modern type of money, the bank deposit. Directly or indirectly, a substantial percentage of the bank deposits of the country were put at the disposal of the nation through the purchasing of Federal Government bonds by individuals and banks.

The financing of World War II meant that the Federal Government must raise about 398 billions of dollars for the six years 1940-1946. Only 176 billions, or 44 percent, came from taxes. The remainder, 222 billions or 56 percent, was raised by borrowing.

Of these 222 billions, approximately 90 billions, or almost 23 percent of the 398 billions raised during the six war years, was raised by selling government securities to the commercial banking system (including those purchased by the Federal Reserve Banks).*

This resulted in a large increase of bank-held government securities. Table XLVII illustrates the situation from 1939 to 1947.

During the same period, the money in circulation varied as shown by Table XLVIII.

* Previously quoted statement by the Chairman of the Board of Governors of the Federal Reserve System.

TABLE XLVII

BANK INVESTMENTS IN THE UNITED STATES

(Millions of Dollars)

	Total Investments	U.S. Govt. Obligations	Other Securities
Dec. 31, 1939	28,719	19,417	9,302
1940	30,422	20,972	9,449
1941	34,511	25,511	8,999
42	54,231	45,951	8,280
43	73,365	65,932	7,433
44	93,446	85,885	7,561
45	109,865	101,288	8,577
46	96,050	86,558	9,491
47	91,909	81,186	10,723

Source: *Federal Reserve Bulletin.*

It is interesting to compare these data. This comparison is shown in Figure 65. It shows that the increase in bank-held government securities, starting with the war in Europe in 1939, was associated with an increase in total money in circulation. But it also shows that a decrease in bank-held government securities after 1945 was *not* associated with a decrease in total money in circulation.

This underlines the very peculiar character of monetary inflation in the United States. In a country where the inflation is mainly due to an increase in currency, its effects are more immediately felt but, barring of course any further inflation, they are soon dispelled. In a country where the monetary inflation is mainly due to a very refined use of the delicate modern apparatus of bank credits, as was the case in the

TABLE XLVIII

TOTAL DEMAND DEPOSITS (ADJUSTED) AND CURRENCY OUTSIDE BANKS

(Millions of Dollars)

Dec. 31 1939	36,196
1940	42,270
41	48,607
42	62,868
43	79,640
44	90,435
45	102,341
46	110,044
47	113,499

Source: *Federal Reserve Bulletin.*

United States, the effects of inflation are somehow delayed, almost unnoticed, but they are then felt for a long time and finally result in substantially higher price levels. Inflation acts in some respects as a time bomb would. It does not explode suddenly but it is there and is due to explode. In fact, monetary inflation was not felt in the United States until many months after the end of the war and the termination of wartime controls, although, as Figure 65 shows, a potential inflation already existed.

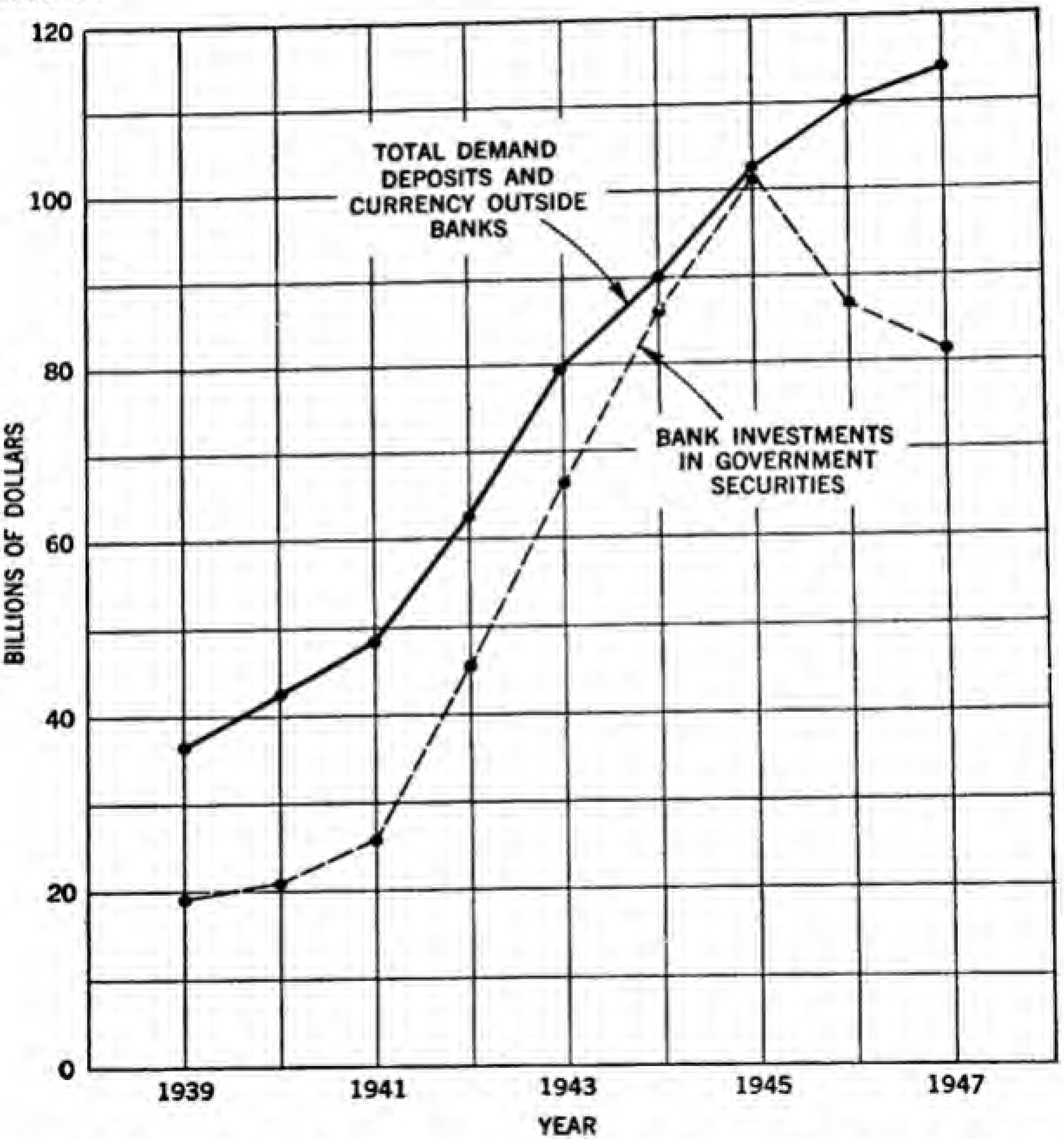

Figure 65. Comparison of Total Bank Deposits and Currency Outside Banks with Bank Investment in Government Securities for the United States, 1939–1947

Then, after it began to be felt, inflation developed and was increasingly felt, although the exceptional circumstances that provoked it had ceased to exist. The reason is that the potential inflation contained in the expanded debt was slowly converted in more and more inflation of money in circulation by the complex processes of debt retirement, debt support by the Federal Reserve System, increase of bank deposits, increase of bank reserves, and the extension of new bank credits.

These processes, which could be compared to the melting of snow and ice into the high waters of the spring season after a long and hard winter, have been described as follows by the Chairman of the Board of Governors of the Federal Reserve System, Thomas B. McCabe, in a statement before the House Banking and Currency Committee:

> Sales of United States Government securities in the market by banks and others have not been absorbed by purchases on the part of other investors. In order to keep the prices of Government securities from declining, the Federal Reserve System has continued to carry out its wartime responsibility of supporting the market by buying at relatively stable prices securities offered for sale and not purchased by others. The result of these purchases by the Federal Reserve Banks is to supply additional reserve funds to banks. Because of the fractional system of reserve requirements, these new reserves in turn provide the basis for an increase in bank credit that may be many times the amount of new reserves obtained.
>
> In the postwar period these reserves supplied the basis for an increase in bank credit in response to an active demand for loans to finance the operations and expansion of the business system in an area of high demand, accelerated activity, rising costs, and rising prices. (On August 2, 1948. Reprinted in the *Federal Reserve Bulletin*, August, 1948. See also a similar statement by Marriner S. Eccles, then Chairman of the Board, in *Federal Reserve Bulletin*, December, 1947.)

II. CREDIT INFLATION COMBINED WITH MONETARY INFLATION

What is the value of today's dollar in terms of yesterday's dollar? Estimates vary greatly. Some have estimated that the 1948 dollar, for instance, is worth about 40 cents in 1939 and that the 1956 dollar is worth about 89 cents in 1948, which is equivalent to about 36 cents, 1939. Others dispute the point and argue that such an estimate is too low or too high for this or that reason.

Although such estimates may give a useful approximation of the situation as a whole, it should be clearly understood that the extent of an inflation cannot be measured in such simple terms. One reason is that credit inflation is sometimes added to monetary inflation, as has

been the case in the United States during the decade following World War II. As indicated in the above statement by Thomas B. McCabe, one type of inflation may actually stimulate the other. In addition, the two types of inflation have a combined effect, and this makes it difficult to measure the impact of either, especially if one considers that credit inflation is subject to comparatively frequent variation. Furthermore, it should be noted that the evaluation of the ultimate result of inflation as such, whether monetary or credit inflation or a combination of both, is a complex matter in any case because of conflicting psychological, monetary, social, and economic factors.

If, by chance, it was estimated that the unit of length measurement, the foot, is too long and if, by chance, it was ordered by Act of Congress to shorten it by one third, it would take years before the population conformed to the use of the new length of the foot. It would probably take more than a generation.

In the same way, psychological factors influence the acceptance of the results of inflation. For the average citizen, "a dollar is a dollar," and he is inclined to believe that prices are going up rather than to realize that the economic yardstick with which prices are measured is changing—as it is, in fact. Is it not difficult, sometimes, when sitting in a train, to decide whether one's own train or the one coming in the opposite direction is moving? How then can the average citizen who has to pay a dime or twenty cents instead of a nickel for his transit fare know for sure whether, in the final analysis, the price of the fare has increased or whether his dime or twenty cents of today is worth about the same as his nickel of yesterday?

Such psychological factors will act as a brake against inflation, the extent of which, as measured by the price level, will lag behind its extent as measured by the increase in the volume of money in circulation.

Indeed, such psychological factors will not be equally influential in the various sections of the national economy. The wholesaler, the importer, the industrialist, the stock market operator, the labor unions, all follow the real monetary situation much more closely and adapt themselves much more quickly than does the general public. This is illustrated by the fact that many labor contracts have recently provided for adjustment based upon variations of the cost-of-living index. This is another way of saying that actual wage rates will compensate for any variation of the economic yardstick, the dollar.

Social factors also are influential. Governments cannot allow inflation to be felt too quickly or to its full extent in every field. For instance,

experience shows that in every country such control as the rent control, among others, is maintained over a long period of years after the start of an inflation.

The arising of new economic conditions, the actual velocity of money circulation, and extensive new technical developments may also be influential in counteracting the effect of inflation, and it is always difficult to evaluate the relative influences of such conflicting factors. Therefore, neither the price level of specific commodities alone nor the increase in total money in circulation alone can be used to determine the extent of inflation which cannot be expressed by a definite ratio. No attempt should be made to do so. Moreover, it is useful to determine its order of magnitude.

Table XLIX shows the increase in money and credit from 1940 to 1947 and then to 1956. For the reader who wishes to follow up the subject by measuring actual increases or decreases at the time he reads

TABLE XLIX

INCREASE IN MONEY AND CREDIT 1940–1956

	Amount in $ Billions			Rate of increase	
	1940	1947	1956	1940 to 1947	1947 to 1956
	$B				
Currency (outside banks)	6.7	26.3	27.1	392%	103%
Demand deposits (adjusted)	31.9	82.2	108.9	257%	132%
Total	38.6	108.5	136.0	281%	125%
Installment credit	5.4	6.4	27.7	118%	432%
Non-installment	2.7	5.4	7.8	200%	144%
Total	8.1	11.8	35.5	145%	300%

this table, the necessary data are published monthly in the *Survey of Current Business*, issued by the U.S. Department of Commerce. Table XLIX clearly shows that:

the period 1940-47 was characterized by monetary inflation rather than credit inflation (currency in 1947 was 392 percent of what it was in 1940)

the period 1947-56 was characterized by almost no change in currency circulation, a moderate increase in demand deposits (132 percent) and by the development of credit inflation (increase in credit was

300 percent for all credits, reaching 432 percent for installment credits)

Inasmuch as some but not all of the credit inflation is included in the monetary inflation (in the form of deposit money), it is not possible to measure the combined increase in money and credit that would represent the net combined inflation.

If we now want to evaluate the impact of such inflationary trends, we have to turn to such indicators as the cost of living indexes shown in Table L. The reader who wants to follow up for later years will find current data in the monthly *Survey of Current Business* and historical data in the yearly *Statistical Abstract of the United States,* both published by the U.S. Department of Commerce.

TABLE L

COST OF LIVING INDEXES

	1940	1947	1948	Jan. 1956
		1935–39 : 100		*1947–49 : 100*
Consumers' price index	100.2	159.2	171.2	114.6
Retail prices of foods	96.6	193.8	210.2	109.2
		1926 : 100		
Wholesale prices				
All commodities	78.6	152.1	165.1	111.9
Farm products	67.7	181.2	188.3	84.1
Foods	71.3	168.7	179.1	98.3
Metal and metal products	95.8	145.0	163.6	145.1
Building materials	94.8	179.7	199.1	——
Tires and tubes	——	——		151.8
Paper	——	——		134.6

Table L shows that after World War II the general price level was on the average, slightly more than double of what it was before the war. At the same time, as shown in Table XLIX, the total money in circulation (total demand deposits, adjusted, and currency, outside banks) had increased from:

$ 38.6 billion in 1940
to $108.5 billion in 1947

or an increase of almost 300 percent.

From 1947 to 1948 the total money in circulation remained un-

changed at the level of about $108 billion. Yet, during the same period, there was a substantial increase in cost of living as shown in Table L. This illustrates the fact that an inflationary trend is characterized by some sort of delayed action, the normal consequence of what can be called the "moment of inertia" of social and economic life.

The increase of the cost of living between the 1947–1949 period and 1956, as shown in Table L, was, on the average, about 120 percent, close to the increase in money inflation, but much less than the increase in credit inflation.

Such figures clearly indicate that the cost of living was influenced by the inflationary trend but did *not* keep pace with it. The explanation is quite obvious in our economy. It is well known that during the same period, the supply of goods and services has also been greatly increased, thus balancing to some extent the inflationary trend.

The increase in prosperity during the inflationary period that has just been discussed is measured by such factors as the increase in national income * from:

$ 81.6 billion in 1940
to $197.2 billion in 1947
$221.6 billion in 1948
$324.0 billion in 1955

III. CONSEQUENCES OF INFLATION

Socially, a substantial inflation has very serious consequences. It threatens the way of life of whole segments of the population, creates maladjusted situations, and creates a general feeling of insecurity and discouragement—all easily converted into despair and political agitation when the impact of inflation becomes too brutal, as the experience of other countries has shown.

The economic consequences—the ones we are concerned with in this book—deserve also the most serious consideration. Some are specifically related to credit inflation; others are related to inflation as such, whatever its origin is. The latter are of two kinds—short run effects and long run effects.

A. CONSEQUENCES OF CREDIT INFLATION

As already indicated, experience shows that monetary inflation can be considered as an irreversible process. The same is not true for credit inflation, which can turn into deflation in either or both of the following

* For a definition of national income, see Chapter XV.

ways: 1. Deflation can result from the stoppage or reduction of further credits. Past credit has to be repaid regardless of the opening of new ones. This repayment may cause deflation because it is somehow mortgaging the available money. 2. Deflation can even occur although credit is still available. This can be the case when the credit inflation has reached such a point that individual borrowers are unable or unwilling to borrow further.

How far can credit inflation go and still be considered a sound and healthy stimulant of economic life? At what level does it create a risk of dangerous deflation, likely to result in economic recession? This matter has been given considerable attention in recent times, and it is probably one of the most controversial issues of our modern economy.*

B. SHORT RUN EFFECTS OF INFLATION

These are the effects of inflation that are related to the increase in effective demand, regardless of whether inflation is due to an increase in money or an increase in credit.

Prices continuously change, even if there is no inflation. But the changes in the absence of inflation are of much lesser magnitude, as shown, for instance, by the variations over a period of years of price indexes. Table LI shows such variations for a few indexes chosen at random.

TABLE LI

VARIATION IN FOUR SIGNIFICANT INDEXES

	Absence of Inflation Period 1929–1940		Value as of Dec. 31, 1947 under the Impact of Inflation
Consumers' price indexes	Highest 1929:	122.5	167.0
(1935–1939: 100)	Lowest 1933:	92.4	
Retail price of foods	Highest 1929:	132.5	206.9
(1935–1939: 100)	Lowest 1933:	84.1	
Wholesale prices of farm products	Highest 1929:	104.9	196.7
(1926: 100)	Lowest 1932:	48.2	
Wholesale prices building materials	Highest 1929:	95.4	191.0
(1926: 100)	Lowest 1932:	71.4	

* See *1956 Economic Report of the President* (p. 94). See also Federal Reserve Board, *Consumer Instalment Credit*, Washington, 1957 (especially Part I, Vol. I, which is an extensive study of credit inflation).

Such figures illustrate how much smaller is the range of variations due to a change in general economic conditions than when it is due to inflation. The comparison is illustrated by Table LII.

TABLE LII

GREATEST VARIATION IN FOUR SIGNIFICANT INDEXES

(Variation from the base years, 1926 or 1935–1939)

	Absence of inflation (1929–1940)	Inflation (1947)
Consumers' price index	22.5	67.0
Retail prices of foods	32.5	106.9
Wholesale prices—farm products	51:8	96.7
Wholesale prices—building materials	28.6	91.0

Such a difference explains by itself why adjustments, even if they may cause hardships, are easier in the case of simple economic fluctuations than in the case of inflation.

Experience shows that, after an inflation, it takes a long time before prices adjust themselves to a new but higher level of equilibrium. For a long period, the economy is disturbed. The situation is somewhat comparable to the one that would exist if the inch measure of length were, by successive and progressive steps, reduced to a half or a third of its original length, especially if the reductions were not clearly defined and not universally recognized.

One of the most widely publicized consequences of the instability originated by inflation is the so-called wage-prices spiral. But this is only one side of the question. What happens, in fact, is that the exchange of goods and services is based on a yardstick of changing value.

The value is changing in time because the effects of the inflation are delayed and progressive. The value is even changing from place to place and transaction to transaction because of psychological factors. Some individuals would ignore the extent of the inflation, for lack of information, while others may be inclined to exaggerate its real magnitude.

Furthermore, social and political consideration may cause public bodies to take various measures delaying the results of inflation, such, for instance, as the control of prices. It even happens that price control will be limited to some fields, the rent of housing, for instance, while others are left free, which creates permanent conditions of maladjustment.

In the end, a new equilibrium is found, barring further economic disturbances. But experience shows that it takes a long time.

Meanwhile, the businessman has to adjust himself the best he can to a temporary disequilibrium. No general rule can be given for meeting such a situation, characterized by a complete lack of logical behavior.

C. LONG RUN EFFECTS

Once the situation is more or less stabilized, a rational treatment can be considered. Even before such a stabilization becomes an actual fact, it is advisable for the businessman to prepare the way for adjusting himself to the new conditions to be expected.

The first step is to determine within reasonable limits of accuracy the order of magnitude of actual inflation after it has reached its level of equilibrium. We have seen in the first part of this chapter how a reasonable estimate may be attempted.

The second step is, then, to evaluate the long run consequences of such a change in value as far as the assets, liabilities, and proprietorship of the business are concerned.

1. Assets

Some assets, such as cash, receivables, and inventories, more or less adjust themselves to the new value of the money. But the fixed assets purchased before the inflation period are still accounted for at their old value. This creates a double problem.

First problem: The balance sheet does not reflect the true situation. There is a systematic undervaluation of actual assets. In some instances, a re-evaluation of assets might be justified. The surplus resulting from this re-evaluation should, of course, be separated from other kinds of surplus, as it is really the result of an accounting adjustment, not an actual profit.

Second problem: The profit and loss statement reflects the profit (or loss) which is the difference between the sales and the cost of goods sold plus other expenses. Some of the costs are still accounted for at the former value of the money, especially the depreciation. The result is that the profit is partly artificially inflated (or the loss unduly minimized). Some manufacturers are well aware of the situation and have suggested an additional depreciation based on the replacement value of the assets. This method, however, is in direct opposition to the very nature of depreciation.

Depreciation is an allocation of a capital expense over a period of years.* It is, therefore, a very definite and stable amount. To base depreciation on the replacement value, which may change from day to day, is introducing a dangerous element of instability in accounting and should not be encouraged. There is a way out of the difficulty by creating a "reserve for increase in replacement price of assets."

A reserve, by definition, is an amount of money put aside to face a future liability or expense, the amount of which is or is not precisely known. This is exactly the case. Due to the devaluation of the money, the manufacturer, through depreciation, is nominally reconstituting his capital but, *really*, he is *not*. The nominally accurate but really insufficient depreciation expense causes him to use part of his original capital to increase his apparent profit.

The exact amount of capital money being actually made part of the profit is not accurately known. Its best approximation will come at the time of replacement, by comparing the replacement value of the machinery with its original value. Even at that time, owing to technical changes and certain other causes, an exact appreciation of the facts will probably be impossible. One should endeavor to arrive at a reasonably close estimate. Among others, three factors should be considered:

1. How comparable to the former asset is the replacement asset? Because it is obvious that if the increase in price is due not only to the devaluation of the money but also to the decision to purchase a better machine, the problem is not at all the same one.

2. What is the salvage value of the machine? Because, owing to inflation, in some cases the salvage value may be much more than could have been expected, thereby reducing the capital loss.

3. How was the purchase of the original asset financed? If it was financed by the issue of bonds, the devaluation of the money acts both ways: on the one side on the real value of the depreciation and on the other side on the real value of the amortization of the debt. In this case again, the problem is entirely different. More will be said on this question in the section on liabilities.

But enough is known now to see that there is a difficult problem of estimating the amount by which the depreciation cost should be increased. It is practically impossible to make such an estimate before the replacement value of the asset is exactly known. It seems advisable, therefore, to keep the concept of the depreciation, its clarity

* See Chapter IX.

and fixity, and to compensate a possible loss in capital by the establishment of a reserve.

When the amount of the loss in capital can be computed, such an amount is transferred to a surplus amount and the remnant of the reserve, if any, is part of the current profit—like a tax refund, for example. It should be clear that neither method of accounting—by supplementary depreciation or by creation of a new type of reserve—is acceptable to the Internal Revenue Service. From the point of view of Federal taxes, the profit should be computed on the basis of the nominal depreciation (purchase value). But, independently from any consideration of taxes, it is good policy to present the results of a business as they really are.

A depreciation based exclusively on the purchase value means, in time of inflation, a depreciation based on the former value of the money. Profits computed after such a depreciation are unduly inflated by an apparent increase of net income and a real loss in capital.

2. *Liabilities*

Conversely, the debts of the business, if contracted before the inflation, are, in fact, substantially reduced. This, in itself, might automatically compensate for the effect of inflation on depreciation. If the assets being depreciated have been bought on borrowed money, there is obviously no justification for a reserve "for increase in replacement price of assets."

3. *Proprietorship*

This is where inflation may have its most disturbing effect. The decrease of the value of money means that for the same volume of production, there is a corresponding increase in capital needs. Directly or indirectly, the business's capital should be increased either through reinvestment, borrowing, or non-distribution of dividends.

For most businesses, the stimulation given by the very process of inflation, creates a surplus of profits that will compensate, to some extent, for the loss in the real value of the capital.

For corporations, however, the problem remains of retaining such surplus in the business instead of distributing it as dividends. During the postwar years, 1946-1947-1948, most of the United States corporations pursued a policy of retaining in the business a very substantial part of the earnings. Such a policy may somehow help solve temporary difficulties in financing the business but, in the long run, it may contribute to a reduction of that portion of the national income which is

used for consumption purposes. It may be a step toward reducing the "effective demand" below the level required for the continuation of healthy economic conditions. This calls attention to a point, the importance of which cannot be overemphasized.

This chapter, discussing inflation, has shown the dangers of the conditions in which "effective demand exceeds the over-all supply of goods and services." But the converse, in which the over-all supply of goods and services exceeds effective demands, is just as dangerous, even though for opposite reasons, and is the origin of the unhealthy economic stagnation called a depression.

How can effective demand be evaluated and forecast by the businessman? What are the main factors responsible for a harmonious relationship of effective demand to supply of goods and services? Such questions will be studied in the next chapter.

XV

PRODUCTION AND EFFECTIVE DEMAND

IN FORMER YEARS, the sum of production wages and salaries and direct material expenses, i.e., essentially *variable expenses* represented most if not all of the total expenses of the industrial enterprise. Thus, if sales of a new product were slow in developing, or if an already well-marketed product showed a recession in sales, the manufacturer was able to face the situation with no greater trouble than a smaller profit than expected.

In modern times things have changed fundamentally. Modern industry, through the application of entirely new methods of production and distribution, opens practically unlimited possibilities of increasing the population's standard of living by producing greater quantities of goods at an ever decreasing total cost. Yet such new methods require a minimum level of production to support the burden of the continuously increasing proportion of *constant expenses.** The recent trend toward using more and more efficient but also more and more expensive

* For the distinction between variable and constant expenses, see Chapter IV.

equipment (currently known as the trend toward automation) has greatly contributed to this increase in the proportion of constant expenses. The increase in research and development and the increase in advertising expense have had a similar effect. So have the recent trends toward retirement and pension plans and toward "guaranteed annual" wages. This latter development transforms a typically variable expense (direct labor), or at least a portion of it, into a constant expense.

As the years go by—as new methods of production are being developed, as guaranteed annual wages become the rule, as retirement plans expand—it can be expected that the proportion of constant expenses will further increase.

The pilot of a modern jet plane travels faster than sound. Unlike the old-time horseback rider, however, he cannot slow his pace at will lest he fall and die. The span of his wings supports him only above a given minimum speed.

Modern industry, in like manner, must maintain its production above a given minimum rate or else the enterprise goes out of business.

The businessman ought to know this minimum rate of production—the break-even point of his business below which "speed" he cannot operate. But it is not sufficient for him to know only what is the minimum rate of production required; he also must know how to find a market for such a production.

How can sales be maintained at the rate required to make production economically possible? Who will buy at a sufficient price in sufficient quantity?

Better presentation of the goods, more clever advertising, wiser pricing and, generally speaking, a better marketing policy enable a given business, operating either directly or through jobbers in a given market, to maintain or increase its share of the total business as compared with its competitors' share.

Even if the competitors' resistance tends to limit such effort, the limit is always more or less a flexible one. The more dynamic enterprise has a good chance of being successful in expanding its market. There is, however, a second limit to its efforts in this direction. This second limit is determined by the *effective demand,* meaning the demand for a product which is supplied at a price the customer can and will pay. Beyond this second limit, the business cannot expand, whatever its vitality, whatever its influence on the consumers' tastes and wants, even if it were able and permitted by law to eliminate all its competitors from the market.

It is of vital importance for the businessman to know how to ap-

proximate the effective demand. It is the purpose of this chapter to deal with this question. Obviously, the more customers there are and the more money they have to spend, the more effective demand there is. It is necessary, therefore, to study the two factors which, economically speaking, determine the effective demand, namely:

I. The population
II. Its purchasing power.

I. POPULATION

There seems to be a general pattern of growth of populations. Its very existence suggests the possibility of forecasting future conditions by extrapolation. The danger of such extrapolations is obvious and well known. But, if carefully utilized, if projected in a reasonably distant future, if taken for what they really are, just plain probability, such extrapolations may well be extremely useful. In fact, their usefulness is recognized by many businesses which largely base their investment and long-range production policy on them and often obtain results of astonishing accuracy. Very refined techniques of forecasting sales on this basis have been developed. In some instances, researches on changes in population are so essential that they are considered one of the main factors of production planning.* Such is the case of some public utilities, which give a careful and continuous attention to population growth in the territory in which they operate.

The Long Island Lighting Company, for instance, considers changes in population the prime factor affecting company sales and spends much time and effort in studying population trends. Its forecasting department's methods are described as follows.†

> Careful and continuous population studies are made of the areas served by the Long Island Lighting Company. These studies take into account the birth and death rates, the migration of people, new construction, and other similar factors. From these studies a trend of population is established and forecast. Regular reports are made by local managers on construction and applications for service. They also make reports for new industries. The reports are studied for possible effect on population-meter ratios.
>
> By applying the forecasted population-meter ratio to estimates of future population, the number of meters in use can be forecast.

Other kinds of businesses are affected not only by changes in the total population of a certain area, but also by changes in the composi-

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* For more details, see National Industrial Conference Board, *Studies in Business Policy No. 25*, "Forecasting Sales."
† *Ibid.*

tion of the population, its characteristics, habits, etc. The data on population trends are not always used to their full extent although they are available for many areas. Their availability should be better known by business.*

Recognizing the importance of population data as to growth, character, etc., a prominent business research organization, serving many industrial enterprises, has advised its clients in the following terms:

> YOUR LONG-RANGE MARKET . . . With developments popping fast & urgently, it's sometimes hard to get away from the immediate grind for a look ahead. But many executives are taking time out to study some new market data . . . *population* figures which, in the last analysis, are the basis of all sales, especially if your sales policy is in any way geared to:
>
> . . . Total population.
> . . . The number of people in various age groups.
> . . . The number & distribution of households.
> . . . Types of families.
>
> DO THESE CHANGES AFFECT YOU? . . . There have been important shifts . . . Here is some of the more significant population information for sellers, just published in a special census report. . . .
>
> 1. *The baby boom hit its peak in 1947 . . . census estimates 3,720,000.* (The figure was only 2,360,000 in 1940.) Obviously this means a huge increase in the market for goods for young people . . . now and in the future. For example, if you sell a product for 7-year-olds, your market will grow; in 1954 it will be about 60% larger than it is to
>
> 2. *But the baby boom is slowing up* . . . (rate of marriages is dropping). A slump to 3,250,000—maybe even lower—is expected for this year.
>
> 3. *Shift from farm to city is continuing* . . . concentration of households in non-farm areas is growing—83% in '47 as compared to 80% in '40.
>
> 4. *Net growth in the number of households in the years* '40–47 was:
>
> . . In Northeastern states, about 12%.
> . . . In North Central states, about 10%.
> . . . In the West, about 25%.
> . . . In the South, no significant change.
>
> 5. *The number of related persons living in one household is dropping,* from average 3.15 to about 3.07 for U.S. as a whole . . Evidently, sons &

* In addition to the well-known decennial United States Census of the Population, detailed and comprehensive data are available on the subject of the past, present, and probable future population of the United States. See especially: National Resources Committee, *Population Statistics;* Department of Commerce, Bureau of the Census, *Current Population Reports*, such as: Series P. 20—Population Characteristics; Series P. 25—Population Estimates; Series P. 68—Special Census.

daughters moving out to get married account for it; and that should mean great demand for all sorts of household merchandise . . . everything from pots & pans to furniture & rugs, appliances, etc.

This trend has continued. The number of households has increased from 39.1 millions in 1947 to 48.7 millions in 1956, or an increase of about 25 percent in ten years. In fact, the factors mentioned in the above publication have remained as important as they were at the time. New trends will develop in the years to come, which cannot all be anticipated. What can be said, however, is that it will definitely be advisable for the businessman to study these trends and to make a special effort to forecast their impact upon the market available for his products. As stated by the Bureau of the Census: "Estimates of the future size of the national population are often necessary prerequisites for both long and short range planning by business and government." *

A special effort in recent years has been made to analyze the present situation and forecast future population trends, both in terms of total population for the nation as a whole and for each State or local unit and in terms of population characteristics. The Bureau of the Census has developed and published at regular intervals projections indicating the size of the population that would result if specified assumed levels of fertility, mortality, and net immigration were to be realized. As stated in one of its publications: † "By far the most important area of uncertainty in projections of the future population is relating to fertility."

Taking into account this element of uncertainty, projections of the future population are currently made on the basis of four distinct possibilities, series AA, A, B and C, characterized as follows:

Series AA assume that the 1954-55 fertility levels remain constant until 1975

Series A assume that the 1950-53 fertility levels remain constant until 1975

Series B assume that the 1950-53 fertility levels remain constant until 1965, then decline according to a certain pattern

Series C assume the same pattern as series B until 1965, then a more rapid decline.

On this basis, estimates have been prepared for the total population of the United States, which are reproduced in Table LIII.

* Series P. 25, No. 123: 1955.

† *Ibid.*

TABLE LIII

POPULATION OF THE UNITED STATES

(*In Millions*)

1750	1.2	1830	12.8	1910	91.9
60	1.6	40	17.0	20	105.7
70	2.2	50	23.2	30	122.7
80	2.8	60	31.4	40	131.6
90	3.9	70	39.8	50	150.7
1800	5.3	80	50.1	55	165.2
10	7.2	90	62.9		
20	9.6	1900	75.9		

ESTIMATE OF FUTURE POPULATION

	Series AA	Series A	Series B	Series C
1960	179.4	177.8	177.8	176.5
65	193.3	190.3	190.3	186.3
70	209.4	204.6	203.0	196.4
75	228.5	221.5	214.6	206.9

Source: Bureau of the Census (Series P. 25) and *Historical Statistics of the United States.*

This forecast (Series B) is projected in the dotted line of Fig. 66.

The trend of development of the total population is meaningful by itself. It becomes more meaningful, however, when analyzed in terms of the population characteristics. In recent years considerable attention has been given to this aspect of the problem, and data are available which provide useful information on many important factors, such as:

1. Population by area. Current information is available in great details for practically all areas of the United States.

2. The age of the population. There is a trend toward an increasing longevity which will definitely affect the population in the years to come and therefore create an increasing market for goods intended to serve the needs of aged individuals. Table LIV present the data currently available. These data also show the impact to be expected in the years to come from the post-World War II increase in birth rate. This creates a sort of "wave" of increase which affects the five-to-nine-year age bracket and is expected after 1960 to affect the fifteen-to-nineteen-year age bracket.

3. The residence of the population. The farm population represented about one fourth of the total population in 1940. In 1955, it was down to 13.5 percent and it is expected to decrease further.

At the same time there is a distinct trend from the large cities to suburban residence. These two trends will definitely affect many busi-

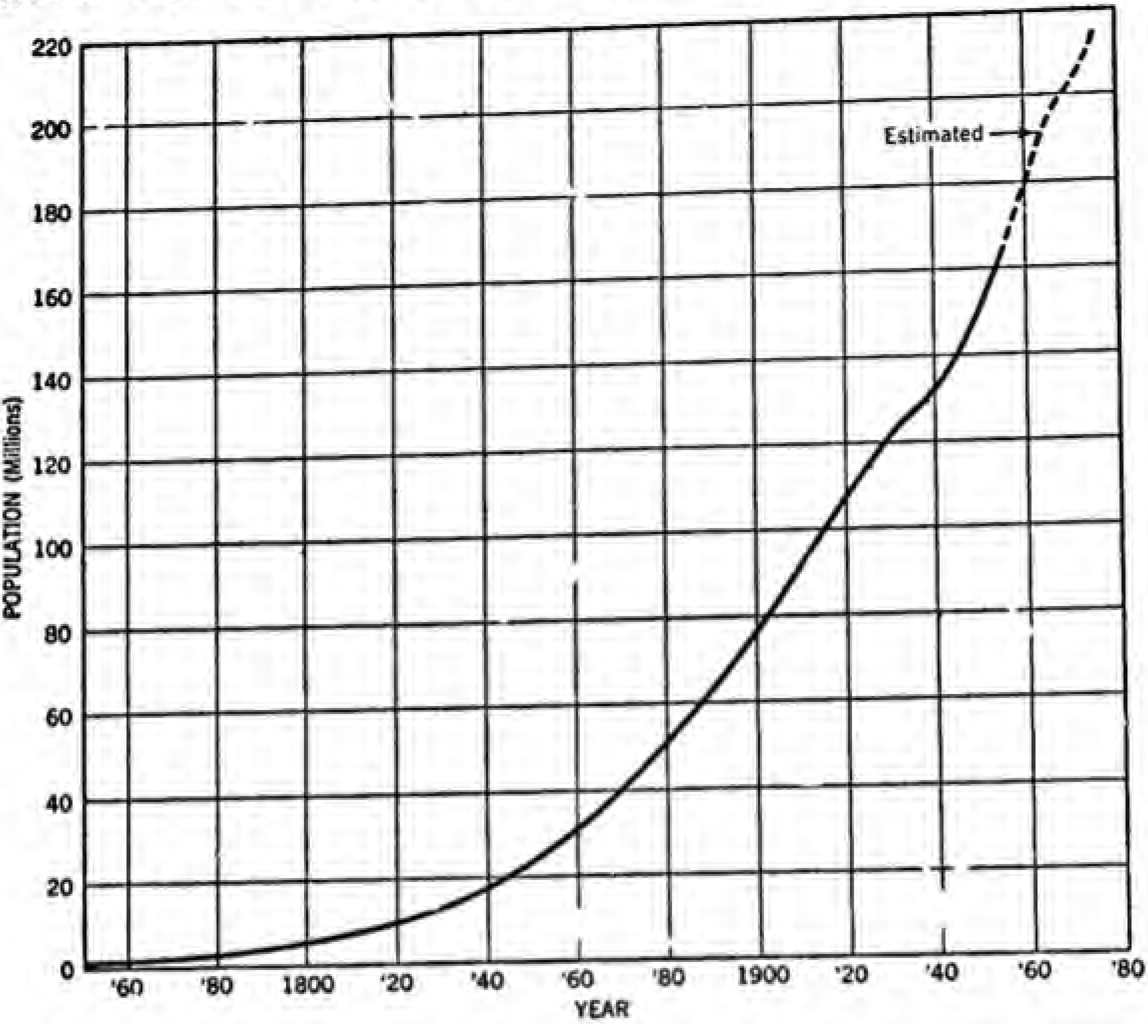

Figure 66. Curve of Population Growth in the United States, 1750–2000

TABLE LIV

POPULATION ESTIMATES BY AGE BRACKET
(*Selected data—in millions*)

Age	1940	1950	1960	1970	1975
5–9	10.7	13.2	19.1	19.7	20.5
15–19	12.3	10.6	13.4	19.2	18.8
65 & over	9.1	12.2	15.8	18.8	20.5

Source: Bureau of the Census (Estimates for Series B).

nesses in the years to come.* They create new habits of life and therefore new needs and new markets.

* See Department of Agriculture. "Migration to and from the Farm," AMS 10; the Census of 1950 shows that between 1940 and 1950 the population increase was 14 percent in the central cities while the increase *outside* of central cities was 36 percent.

Thus it appears that the size of the population and its main characteristics should be carefully measured and studied and that an attempt should be made to anticipate future developments so as to guide high-policy decisions for short range and long range planning.

II. PURCHASING POWER

The power of a waterfall is determined by the volume of the water and the height of the fall. In like manner the *effective demand* (as previously defined) is determined by the size of the population and its purchasing power.

The "size of population" factor having been considered in the first part of this chapter, it remains now to discuss the other factor—its purchasing power.*

In the complex organization of modern economic life, the population's purchasing power is composed of various elements. A customer who wants to purchase given goods at the price for which they are actually offered may consider the following ways:

1. Buy them for *cash*, by using part of his *income*
2. Buy them for *cash*, by using part of his *capital* (dissaving)
3. Buy them for *cash* derived from *borrowed money* (consumer loan)
4. Buy them on *open account credit*
5. Buy them on *instalment*.

An accurate forecast of the customers' intentions and financial possibilities means the difference between failure and success in business. Past experience, knowledge of the market, and bankers' advice will help the businessman in this respect. But today, more than ever, because of the growing complexity of economic conditions, the business-

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* To illustrate the discussion, data will now be used, which, by necessity, are the ones available at the time this book is being written. It is obvious that any conclusions on such matters depend on the given data. They are valid only for a given period.

But situations change and, today, they change very rapidly. The purpose of this book being to help the reader at the time he reads it, an effort will be made to use today's situation only as basis for the discussion. Rather than formulae ready for use, general principles will be developed. To apply such principles to a future situation, the reader must, in turn, have the necessary data. With the purpose of helping him to find rapidly such data, the authors are, in this chapter, extensively quoting their sources, selected from publications easily available and regularly publishing their statistical information (such as the *Survey of Current Business*, the *Monthly Review of the Bureau of Labor Statistics*, the *Federal Reserve Bulletir* *Statistical Abstract of the United States*, etc.).

man must be familiar with the whole problem of customers' purchasing power. The purpose of the following pages is precisely to discuss this problem by studying the three elements of purchasing power:

A. Consumer income
B. Consumer capital
C. Consumer credit.

A. CONSUMER INCOME

The first approach to an investigation of the consumer's income is a study of the aggregate income earned by the whole nation, the national income.

1. National income. The "national income" is defined as "*the aggregate earnings of labor and property which arise from the current production of goods and services by the nation's economy.*" *

Table LV shows the variations of the national income since 1929.†

TABLE LV

NATIONAL INCOME

(*Millions of Dollars*)

1929	87,355	1939	72,532	1949	216,193
1930	75,003	1940	81,347	50	239,956
31	58,873	41	103,834	51	277,041
32	41,690	42	136,486	52	290,177
33	39,584	43	168,262	53	302,129
34	48,613	44	182,407	54	298,335
35	56,789	45	181,731	55	324,048
36	64,719	46	179,289		
37	73,627	47	197,168		
38	67,375	48	221,641		

Source: *Survey of Current Business.*

The above figures give a fair representation of the variations of the economic well-being of the nation as a whole, but they do not neces-

* Definition from the *Supplement to Survey of Current Business*, United States Department of Commerce, July, 1947, "National Income and Product Statistics in the United States, 1929–46."

† Figures for the national income are published by the monthly *Survey of Current Business* of the United States Department of Commerce (also a special yearly number, *National Income Number*) and reproduced by the monthly *Federal Reserve Bulletin*, issued by the Board of Governors of the Federal Reserve System. They are also reproduced by various private publications.

sarily represent the variations in the customers' actual purchasing power in which the manufacturer is interested.

Some factors that are *not included* in the computation of the national income may actually increase the income received by each individual. Such factors are:

a. Net interest paid by Government
b. Government transfer payments
c. Business transfer payments.

Some other factors that *are* included in the computation of the national income may unduly inflate the actual income received by each individual. Such factors are:

a. Undistributed corporate profits
b. Corporate profits tax liability
c. Corporate inventory valuation adjustment
d. Contributions for social insurance
e. Excess of wage accruals over disbursements.

2. *Personal income.* The computation of the personal income eliminates such distorting factors. The personal income is measured as "*the sum of wage and salary receipts, other labor income, proprietors and rental income, interest and dividends, and transfer payments.*" [*]

From the point of view of the businessman, the *personal income* gives him a more realistic figure of the aggregate earnings of his customers than the *national income* does. But it still does not give him an accurate estimate of that part of their income which they can actually dispose of. They have to pay various taxes that have exactly the same effect on their purchasing power as a reduction in income.

3. *Disposable income.* What is left of the personal income after such taxes have been deducted is called the "disposable income," which is defined as "*the income remaining to persons after deduction of personal tax and other payments to general government.*"

4. *Comparison.* Depending on the relative importance of the various factors which influence their components, there will be or will

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[*] Supplement to *Survey of Current Business*, July, 1947. Reference is made to this text (page 8) for a more detailed discussion of the personal income and of the transfer payments.

Ibid.

not be a substantial discrepancy between *national, personal,* and *disposable income.*

Table LVI illustrates how the situation may vary from year to year, according to circumstances. The years 1929, 1933, and 1955 have been selected because they are typical of extreme situations.

TABLE LVI

COMPARISON OF NATIONAL PERSONAL AND DISPOSABLE INCOME

	1929	1933	1955
	(Billions of Dollars)		
National income	87.4	39.6	324.0
Personal income	85.1	46.6	306.0
Disposable income	82.5	45.1	270.5

The year 1929 shows the relationship in a year of peace and prosperity. The difference between national and personal income, partly due to undistributed corporate profits, is moderate. The difference between personal and disposable income, representing the taxes paid, is equal to $2.6 billions or 2.9 percent of the national income.

The year 1933 is a year of economic depression. Due partly to an increase of government payments and partly to the distribution of $2.4 billions of corporate profits previously earned, the personal income is *higher* than the national income.

The year 1955 illustrates the situation in a year of high taxes. The difference between the personal and the disposable income reaches $35.5 billions or 10.9 percent of the national income as compared to 2.9 percent in 1929.

Such comparisons show that the disposable rather than the personal or the national income should be used as an aid for determining the consumer's purchasing power.

5. *Disposable income and consumer expenditures.* The disposable income is only one of the factors to be considered in measuring purchasing power. Everyone knows that some of us do not spend all of our disposable income but save part of it, while others spend more than their disposable income by using part of their past savings or by borrowing money, for example.

However, experience shows that, for the population as a whole, there is a definite relationship between the sales volume of most of the consumer goods and the disposable income. Consumer expenditures,

as the remark has often been made, are very sensitive to income changes.*

The reader realizes that such a remark can be of practical use only if a "quantitative" and not a "qualitative" analysis of the situation can be given. In other words, if the businessman is told that his sales do vary with consumer's income but not told how much, the relationship is of little help, if any at all. Numerous attempts have been made to analyze quantitatively such a relationship. But there are many obstacles. One of them is the instability of the yardstick, the dollar. If the goods sold are measured by the ton—as they often are—and the disposable income is measured in dollars and cents, intricate and always disputable adjustments are required to make the dollar 1957, for instance, comparable to the dollar 1939, or to the dollar 1947. (For a discussion of the variations of the yardstick-dollar see the preceding chapter.)

One danger is to oversimplify the issue; another—and not a lesser one—is to overcomplicate it.

For instance, inspection gauges are usually manufactured under extremely small tolerance limits. The production of plows, however, would not be economically possible if the same limits were prescribed. No farmer would be able to pay the price. Besides no plow needs to be produced under such extremely small tolerance limits—it will do good plowing without it.

Similar considerations should be kept in mind when evaluating the relationship between disposable income and the sale of goods—even more so if the purpose is actually to help business management in its task of sales and production planning. An attempt will be made here to find the best approach to the problem in terms as simple as possible.

The method to be followed is, in many respects, similar to the one previously used for the construction of the profit and loss chart and of the break-even chart (see Chapter IV). At that time, the relationship studied was that of expenses to sales for a given business. We endeavored to determine what pattern, if any, was followed by such relationships. We actually found that normally such a pattern does exist in the form of a straight-line trend. We also found that under certain conditions it was possible to determine the trend of expense in relation to sales for a given business. Such a trend indicates the "normal" behavior of a sales-expense relationship. It can be used for

* See, among others: J. Frederic Dewhurst and Associates, *America's Needs and Resources, A New Survey*, New York, 1955, Chapter 4.

control purposes by calling attention to any departure from the trend and for forecasting purposes, if and when extrapolation is justified.

One may well ask: Is there any functional relationship between *sales* (sales of a product or of a group of products, or even sales of a given business) and *disposable income* as there is a functional relationship between expense and sales? If so, the trend of such a relationship can be used for controlling and forecasting sales in relation to disposable income just as it has been found possible, within certain limits of accuracy, to control and forecast expenses in relation to sales.

While the sales of some goods do not seem to follow as distinct a pattern in relation to disposable income as do other goods, the sales of most consumer goods do follow a definite pattern in relation to disposable income, implying the existence of a functional relationship.*

This pattern for a period of years will now be shown for:

1. The total personal consumption expenditures
2. The personal consumption expenditures for a few important products.

The period chosen is 1929-1955, for which the data shown in Table LVII are available † (see pp. 406-407).

On the basis of these data, Figures 67, 68, 69, 70, and 71 have been prepared. The annual disposable incomes are plotted as abscissas; the annual consumption expenditures are plotted as ordinates. One of the advantages of this method of analysis is that any change in the value of the dollar in abscissa is compensated by the change in the value of the dollar in ordinate. This eliminates the impact of inflation in any study conducted over a period of years.

a. Total Personal Consumption Expenditures

Figure 67 shows the total personal consumption expenditures in relation to disposable income for the years 1929–1955. The graph clearly shows three periods.

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* Extensive research work has been conducted in this field in recent years. See, among others: Dewhurst, *op. cit.;* Rautenstrauch and Villers, *Budgetary Control* (Part I); Winston and Hertzberg, "Regional Trends in Retail Trade," in *Survey of Current Business,* Sept., 1956; Weinberg, "Multiple Factor Break-even Analysis," in *Operation Research,* April, 1956.

† The data prior to 1929 are not readily comparable to the ones now being published by the Department of Commerce, and could not be used in this study without tedious adjustments. (See Introduction to the National Income Supplement to *Survey of Current Business,* July, 1947.)

TABLE LVII

DISPOSABLE INCOME–DISPOSITION OF INCOME–
EXPENDITURES FOR SELECTED PRODUCTS

(In Millions of Dollars)

	1929	1930	1931	1932	1933	1934	1935	1936	1937	1938	1939	1940	1941	1942
Disposable income	83.1	74.3	63.8	48.6	45.7	51.9	58.3	66.2	71.0	65.6	70.4	76.0	92.9	117.5
LESS														
Personal consumption expenditures	78.9	70.9	61.3	49.3	46.3	51.8	56.2	62.6	67.2	64.6	67.5	71.8	81.8	89.7
EQUALS														
Personal savings	4.1	3.4	2.5	—0.7	—0.6	0.1	2.1	3.6	3.8	1.0	2.9	4.2	11.1	27.8
Food	17.5	16.1	13.2	10.1	10.2	12.9	14.6	16.7	18.1	17.3	17.7	19.1	22.4	27.7
Clothing and jewelry	11.0	9.5	8.1	5.9	5.3	6.4	6.9	7.5	7.9	7.8	8.2	8.7	10.2	13.1
Recreation	4.3	3.9	3.2	2.4	2.1	2.4	2.6	3.0	3.3	3.2	3.4	3.7	4.2	4.7
Household operations	10.5	9.3	8.2	6.6	6.3	7.1	7.6	8.6	9.3	8.7	9.4	10.2	11.7	12.2

TABLE LVII–*Continued*

DISPOSABLE INCOME–DISPOSITION OF INCOME–
EXPENDITURES FOR SELECTED PRODUCTS

(In Millions of Dollars)

	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955
Disposable income	133.5	146.7	150.3	159.1	169.0	187.6	188.1	206.1	226.0	237.3	250.2	254.4	270.5
LESS													
Personal consumption expenditures	100.5	109.8	121.6	146.6	164.9	177.6	180.5	194.0	208.3	218.3	230.5	236.5	253.9
EQUALS													
Personal savings	33.0	36.9	28.7	12.5	4.1	10.0	7.6	12.1	17.7	19.0	19.7	17.9	16.6
Food	31.7	34.7	38.3	47.4	53.7	56.6	55.0	57.5	64.5	66.0	68.0	69.7	72.8
Clothing and jewelry	16.2	18.0	20.2	22.3	22.9	23.8	22.8	22.7	24.2	24.6	24.5	24.4	25.6
Recreation	4.8	5.5	6.3	8.9	9.8	10.0	10.2	11.3	11.3	11.4	11.8	12.2	13.0
Household operations	12.5	13.4	14.8	18.7	22.6	24.4	23.5	26.4	27.4	28.9	30.2	30.8	33.8

Source: *Survey of Current Business.*

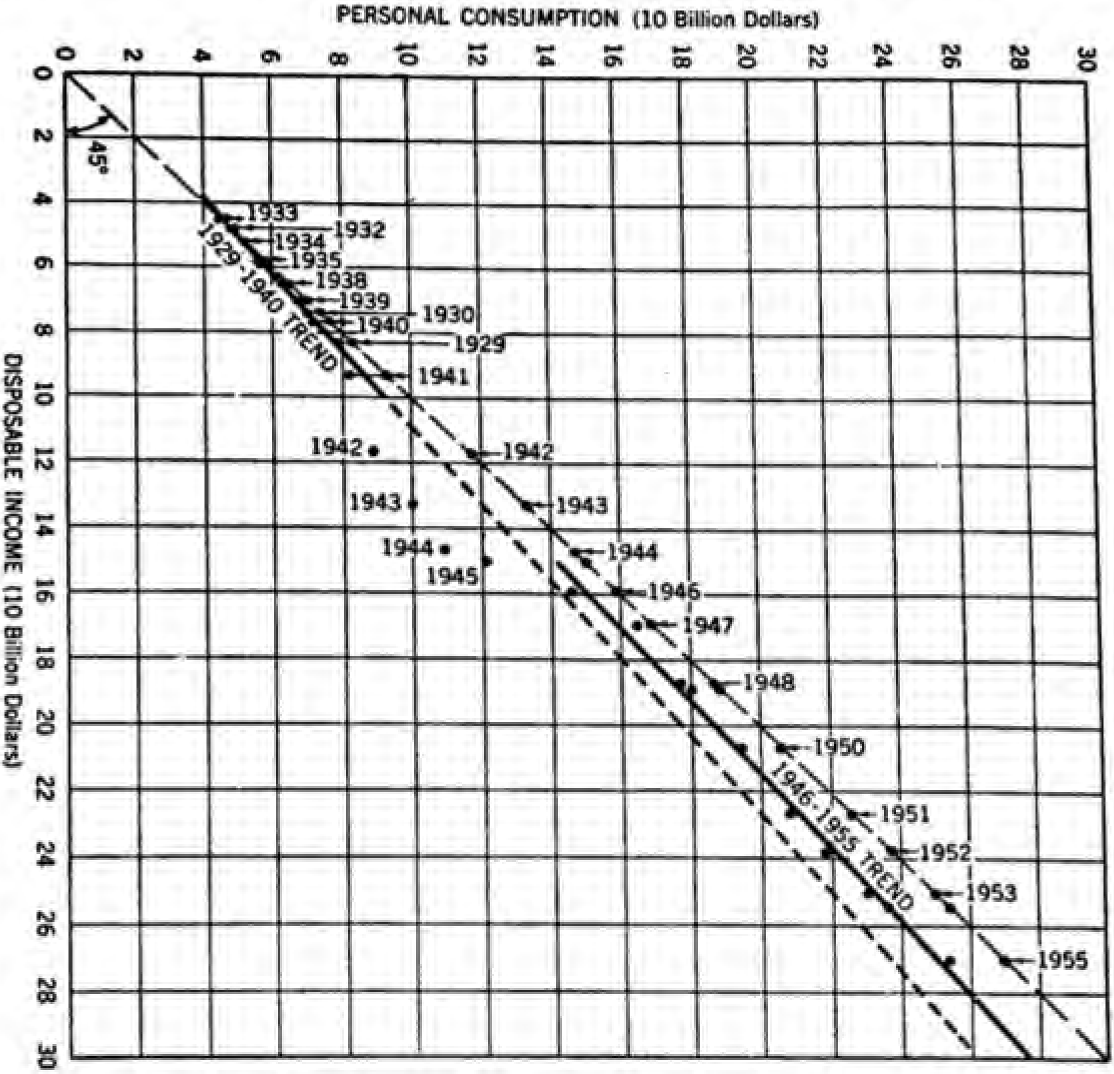

Figure 67. Personal Consumption in Relation to Disposable Income, United States, 1929–1955

First Period: 1929–1940

These twelve years are very interesting ones from the point of view of economic research because:

(1) They include twelve years of changing economic activity (depression period of 1929–1933, postdepression New Deal period, mild recession of 1938, prewar activity).

(2) They exclude the war period and the war-created deep disturbances.

During these twelve years, the trend of the ratio of total personal consumption expenditures to disposable income clearly develops along a straight line, the equation of which is:

$$P = \$7.5 \text{ billion} + 85\% \, D$$

where D is the disposable income, and P is total personal consumption expenditures.

The trend is the same for all twelve years. (We will see, in studying selected expenditures, that two distinct trends are observed for some of them during the same period, one for the years 1929–1933, years of depression, and one for the years 1934–1940, a period of economic expansion.)

SECOND PERIOD: 1941–1945

These are the war years. It is a well-known fact that, during these years, involuntary spending restrictions and a high rate of saving accompanied limitations of civilian goods production.* It was to be expected that consumption expenditures should be *less* than indicated by their trend. It is exactly what Figure 66 shows.

THIRD PERIOD: 1946–1955

As production limitations were gradually withdrawn at the end of the war, consumer expenditures increased far more rapidly than consumer incomes. Many consumers started dissaving on a substantial scale.† Then the credit inflation, discussed in the preceding chapter, started and expanded rapidly.

It was thus to be expected that consumption expenditures should be *more* than indicated by their former trend. Again, this is exactly what Figure 67 shows. The equation of the 1946–1955 trend is:

$$P = \$7 \text{ billion} + 90\% \text{ D}.$$

The difference between disposable income and total personal consumption expenditures is sometimes termed *personal savings*. Graphically, the personal saving for each year is measured by the difference of ordinate between the point figuring consumption expenditures and a 45° angle line similar to the one used for the profit and loss or the break-even chart.

Such a line has been drawn in Figure 67.

b. Selected Consumption Expenditures

A few expenditures have been selected as especially representative.

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* For a detailed study of the subject, see: "Survey of Consumer Finances," by Duncan McC. Holthausen in *Federal Reserve Bulletin*, August, 1947, and August, 1948.

† *Ibid.*

They are the consumption expenditures for food,* clothing,† and recreation and household operations. The four graphs, reproduced in Figures 68, 69, 70 and 71, show a striking similarity with the graph for total expenditures of Figure 67. There are also three periods, which are (with some slight discrepancies noticeable on the graphs):

First period	1929–1940
Second period	1941–1945
Third period	1946–1955

There are some differences in the details which will now be discussed.

Food Expenditures (Figure 68). The first period, 1929–1940, shows two trends, one for the recession years, 1929–1933, and one for the years of economic recovery, 1934–1940. It will be observed that the second trend is above the first one, corresponding to the well-known improvement of the food growers' economic situation.

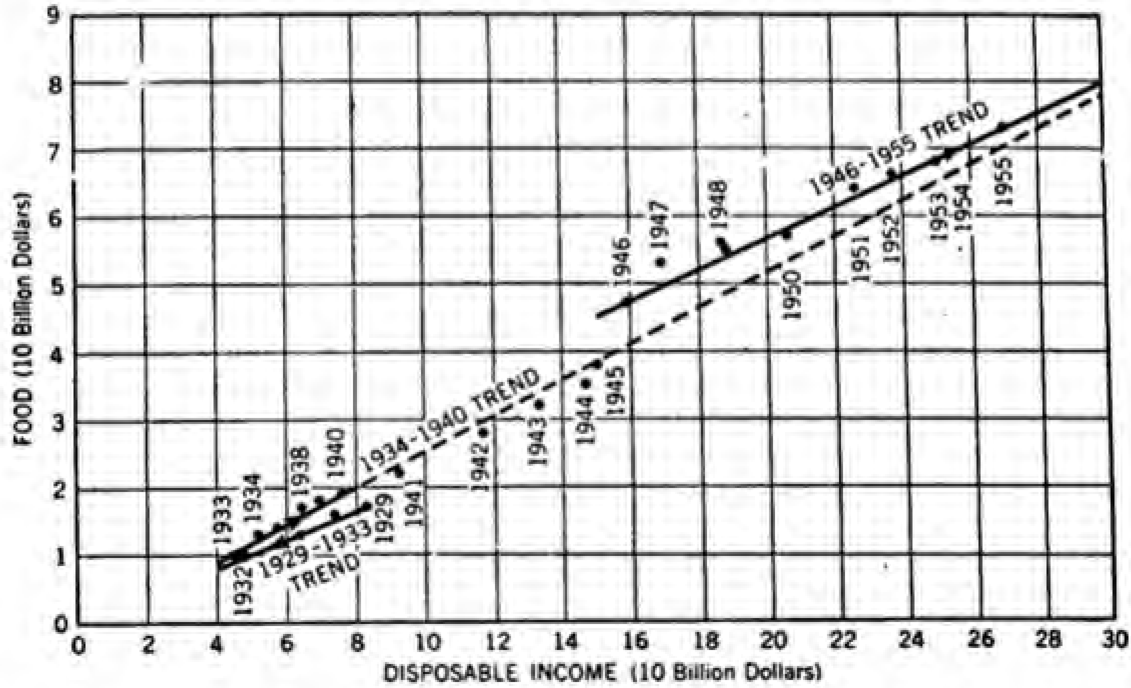

Figure 68. Food Consumption in Relation to Disposable Income, United States, 1929–1947

* Including: Food purchased for off-premise consumption and purchased meals and beverages. Excluding: Food produced and consumed on farms, food furnished government and commercial employees and withdrawn by non-farm proprietors.
† Excluding: Standard clothing issued to military personnel; including: accessories and jewelry.

The second and third periods, 1941–1945 and 1946–1955, do not need special comment. The graphs show that the behavior of food expenditures was similar to that of total consumption expenditures (see page 406).

The trend for food expenditures, as determined during the years 1934–1940, is expressed by the equation

$$F = \$ - 1 \text{ billion} + 26.5\%\ D$$

where D is the disposable income and F the food expenditures; and the trend for the period 1946–1955 is

$$F = \$11 \text{ billion} + 23.3\%\ D$$

CLOTHING EXPENDITURES (Figure 69) and RECREATION EXPENDITURES (Figure 70). Their behavior appears similar to that of the food ex-

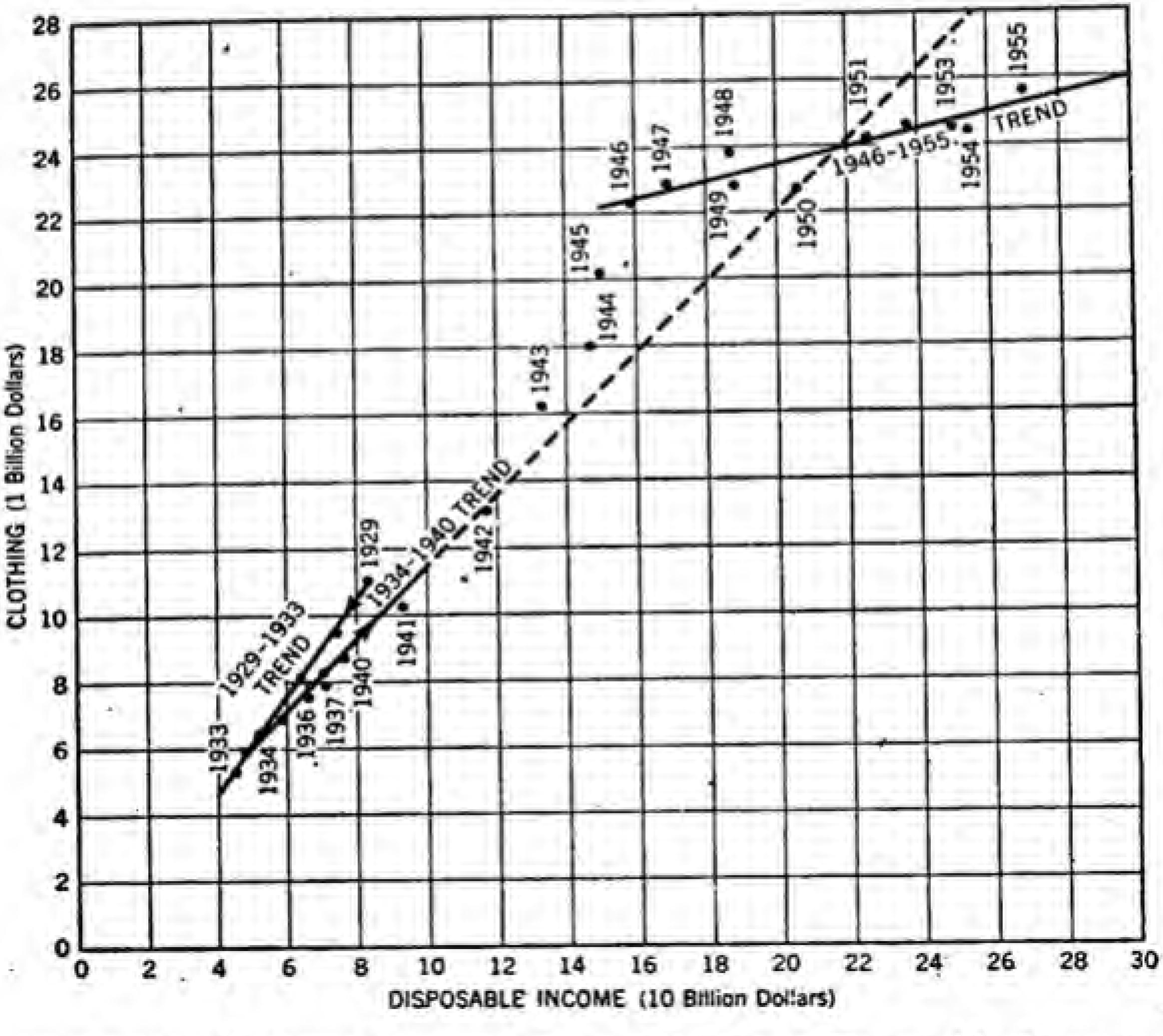

Figure 69. Clothing Consumption in Relation to Disposable Income, United States, 1929–1947

penditures, with the qualification that the trend for the recovery years 1934–1940 is under the 1929–1933 trend while the opposite was true for food expenditures.

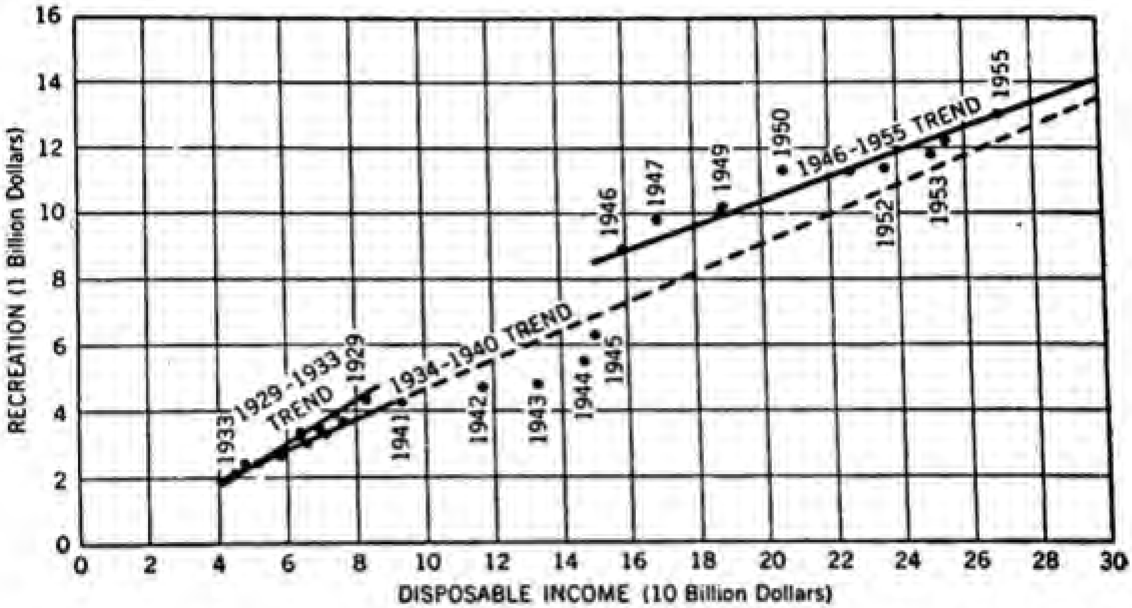

Figure 70. Expenditures for Recreation in Relation to Disposable Income, United States, 1929–1947

The trends can be expressed by the following equations:
For the clothing expenditures—

1934–1940 trend:

$$C = \$1 \text{ billion} + 10.6\% \, D$$

1946–1955 trend:

$$C = \$18.5 \text{ billion} + 2.5\% \, D$$

where D is the disposable income, and C is the clothing expenditure.
For the recreation expenditures—

1934–1940 trend:

$$R = 4.7\% \, D$$

1946–1955 trend:

$$R = \$3 \text{ billion} + 3.7\% \, D$$

where R represents the recreation expenditures.

Household Operations (Figure 71). These expenditures show a greater stability than the other selected expenditures or the total consumption expenditures. This special stability is related to the fact that

a large percentage of the expenditures, classified as household operations, include goods and services sold at a Government-controlled price (electricity, telephone, telegraph, etc.).

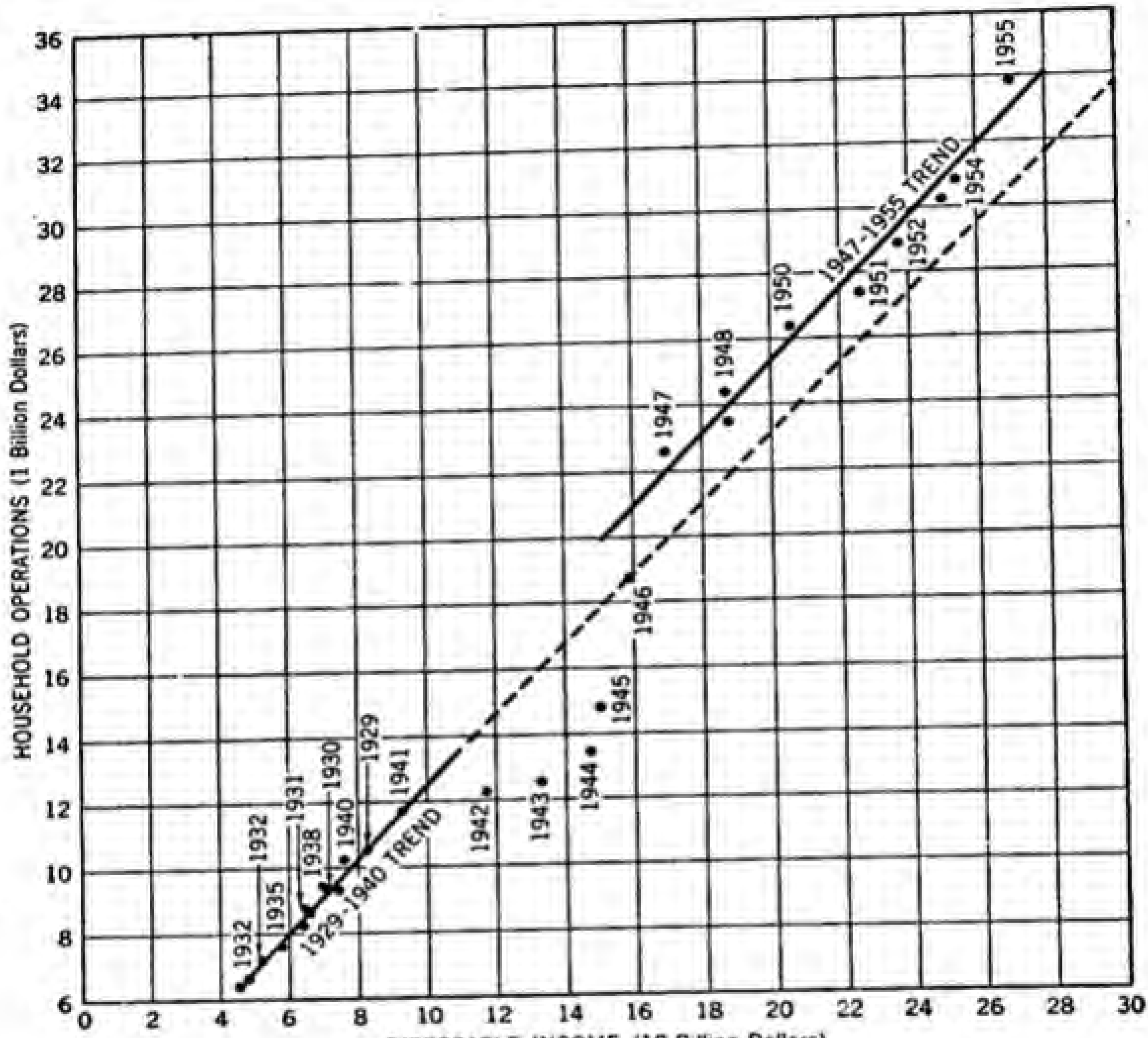

Figure 71. Expenditures for Household Operations in Relation to Disposable Income, United States, 1929–1947

There is only one trend for the period 1929–1940, which is expressed by the equation:

$$H = \$1.3 \text{ billion} + 11.2\% \text{ D}$$

and the trend for the period 1947–1955 is almost the continuation of the 1929–1940 trend. Its equation is

$$H = \$3.3 \text{ billion} + 11\% \text{ D}$$

where H represents household operation expenditures

c. Conclusions

This study of total personal consumption expenditures, and of a few selected consumption expenditures, in relation to disposable income over a period of about twenty years, enables us to draw a few positive and one negative conclusions.

Positive Conclusions:

(1) The striking straight-line trends developed during the twelve years 1929–1940 and the ten years 1946–1955 show the existence of a definite relationship of those expenditures to disposable income.

(2) This relationship, just as that of expense to sale within a business (see Chapter IV), is algebraically described by an equation of the type

$$y = a + bx$$

where y is the expenditure, x the disposable income, a and b are constants.

(3) Some expenditures developed during a period of economic recession, a trend distinct from the one developed during the years of economic recovery or expansion.

(4) A comparison between the prewar and the postwar period shows a substantial increase of the relationship of personal consumption expenditures to disposable income. This increase, as indicated by the two equations previously determined is, on the average, equal to 5 percent of the disposable income. It seems probable that this increase is at least partly related to the credit inflation discussed in the previous chapter. Among the specific expenditures, the clothing expenditures show a substantial change in the pattern of their relationship to the disposable income. Since the end of the war, they have been increasing in relation to disposable income at a much lower rate than during the prewar period, as shown by a comparison between the equations of the two trends. Further analysis of each of the expenses classified under "clothing" (i.e., shoes; women's, children's, men's, and boys' clothing; laundering; jewelry; etc.) would be necessary to provide an explanation of this change. Such an analysis would be useful to any manufacturer whose products are related to these markets.

Negative Conclusion:

A *negative conclusion* can also be drawn, namely, that the departure from the trend during the war (1941–1945) is accounted for and does not disprove the existence of such a trend.

At the time this book is being written, no later data are available. It is left to the reader of a few years from now to plot the data of the years to come. The authors are not in a position to forecast whether such data will or will not show a continuation of the previous trends. But, barring an unforeseen renewal of an economic upheaval such as the one just witnessed during the war, the suggestion is ventured that the reader of the future will be able to determine a definite trend of relationship. It is suggested that the method of analysis of variance used in Table XX could be used to check the validity of the trends thus determined.

d. *Practical Applications. An example: The American Tobacco Company*

The reader who has attentively followed the discussion related to the profit and loss chart, the break-even chart, and their practical applications (Chapters IV, VI, and VII) is now fully familiar with the various uses of such a pattern of relationship.

Just as the existence of a definite trend of expense to sales within a business has been found useful for analysis, controlling, or forecasting purposes, so the trend of consumption expenditures to disposable income can be used for similar purposes in the study of either the whole economic situation, or a given market, or the sales performances of a single business.

The practical applications of such a trend are so numerous that they cannot be described in detail within the limits of this book. They all derive from the fact that such a trend provides a yardstick with which it is possible to measure an actual performance or to estimate the probability of a future one. An example will illustrate.

A few years ago, a group of stockholders brought a suit against the management of the American Tobacco Company. They contended that some bonuses received by the management were unlawful. One of the arguments used by the management for its defense was that it had obtained a spectacular increase in sales. The stockholders' answer was that the increase in sales was due to an increase in tobacco consumption, not to management's ability.

As far as the authors know, neither side in the dispute used a truly scientific method to establish its claim.* The case should have been scientifically decided in the following manner.

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* Extracts of the briefs presented to the court have been published by the magazine *Your Investment* (January, 1940, and July, 1941)

Let us consider * the period 1934–1947. Table LVIII gives the sales record of the American Tobacco Company for these years.

TABLE LVIII

SALES OF THE AMERICAN TOBACCO COMPANY

(*Millions of Dollars*)

1934	222.64	1941	336.93
1935	220.26	1942	422.15
1936	232.96	1943	529.42
1937	242.64	1944	533.37
1938	253.09	1945	557.57
1939	262.41	1946	764.16
1940	285.75	1947	819.63

Source: Annual Reports to the Stockholders.

At first sight, such results are obviously impressive. In 13 years, sales increased by $597 million, almost 270 percent. But, how do they compare with the development of the national market?

For the same period, 1934–1947, consumption expenditures for tobacco products and smoking supplies were as given in Table LIX.

TABLE LIX

CONSUMPTION EXPENDITURES FOR TOBACCO PRODUCTS AND SMOKING SUPPLIES

(*Millions of Dollars*)

1934	1,370	1941	2,073
1935	1,438	1942	2,300
1936	1,540	1943	2,509
1937	1,679	1944	2,509
1938	1,703	1945	2,869
1939	1,773	1946	3,411
1940	1,875	1947	3,880

Source: *Survey of Current Business.*

These expenditures are plotted in Figure 72 in relation to disposable income. It is seen that the increase in total sales of tobacco followed a definite trend, to which it is now possible to compare the trend of the sales of the American Tobacco Company. Such a comparison could be

* The lawsuit involved only the period 1934–1939, but it seems of interest to the reader to extend the study. The sales data of the American Tobacco Company prior to 1934 have not been made public, so that no discussion can be made of the previous period.

made directly on a graph such as that in Figure 72, but the scale of the chart is such that it would be difficult reading.

The reader will encounter the same kind of difficulty every time he tries to compare, on the same chart, the sales of a given corporation with total national sales in relation to disposable income. The reason is that the sales of a given corporation are normally insignificant when studied directly in relation to disposable income which runs into hundreds of billions of dollars. The way out of the difficulty is to study first the total national sales in relation to disposable income, as was done in Figure 72, and then study a given corporation's sales in relation to total national sales of the product under consideration, thereby eliminating the relation to disposable income.

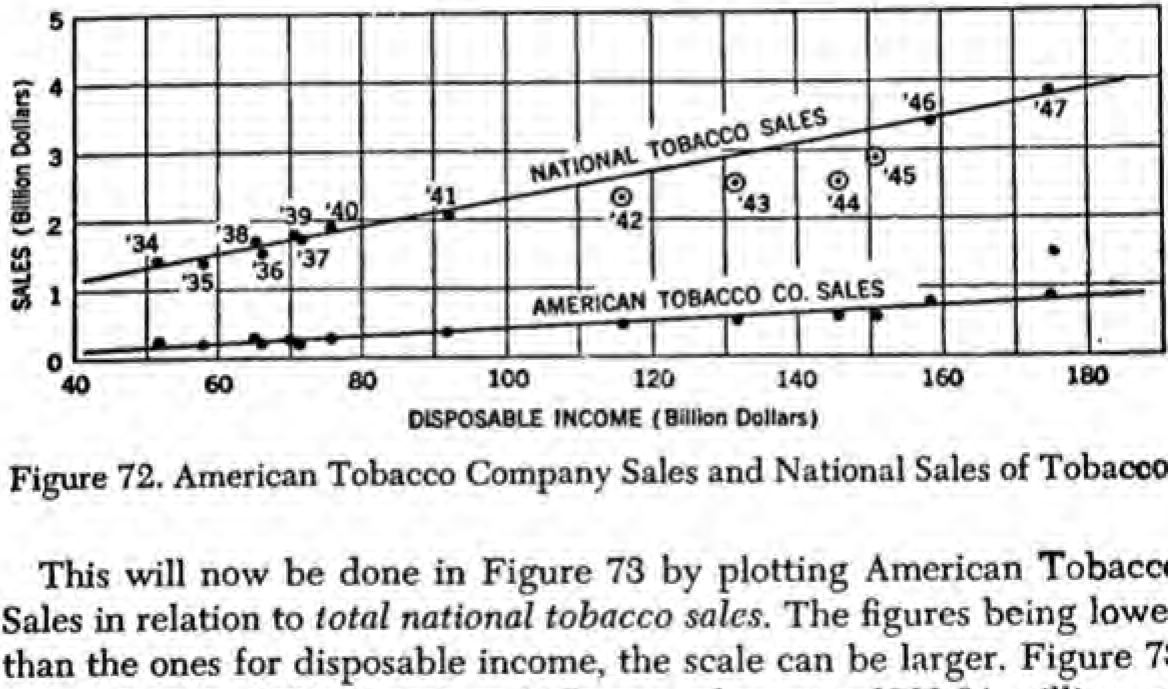

Figure 72. American Tobacco Company Sales and National Sales of Tobacco

This will now be done in Figure 73 by plotting American Tobacco Sales in relation to *total national tobacco sales*. The figures being lower than the ones for disposable income, the scale can be larger. Figure 73 shows that, in 1934, American Tobacco sales were $222.64 million, or 16.2 percent of the total market, which was $1,370 million at that time. If the American Tobacco Company had just maintained its position, its share in 1947 would still have been 16.2 percent of the total market ($3,800 million), or $627 million. Figure 73 shows the trend that *would* have been followed if the sales of the American Tobacco Company, after 1934, had remained at the level of 16.2 percent of total national tobacco sales. On the graph, this trend is called the "16.2 percent control line."

A comparison between the actual trend and the control line will now give us an immediate answer to the question: Was the increase in sales shown by the company the result of its sales policy or of an increase in

national consumption? Figure 73 shows that from 1934 to 1937, while the company s sales increased from \$222.64 million to \$242.64 million, it actually lost some of its share of the market. Starting in 1938, on the contrary, it took more and more of the market. However, it was not until 1941 that the company regained its 1934 share of the total market. (In Figure 73, this is shown by the meeting of the actual trend line with the "16.2 percent control line.")

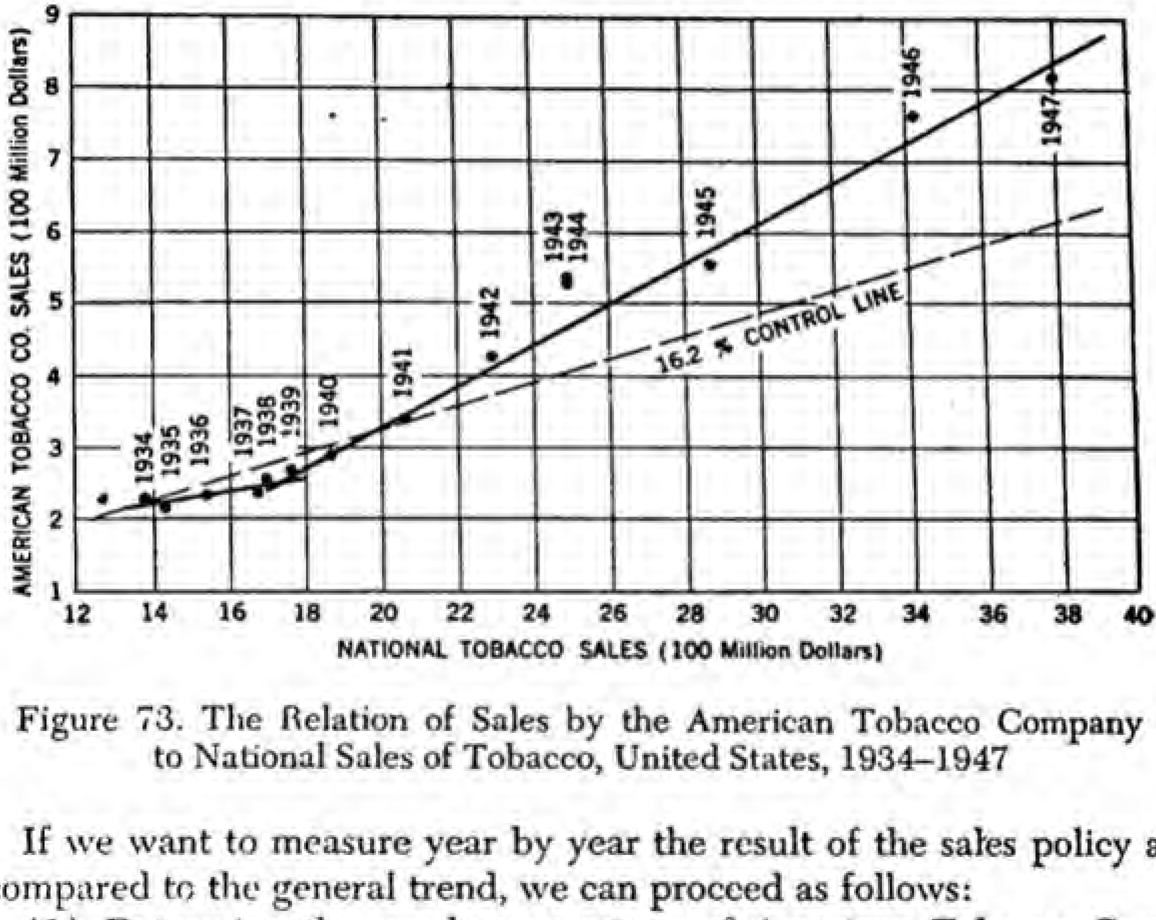

Figure 73. The Relation of Sales by the American Tobacco Company to National Sales of Tobacco, United States, 1934–1947

If we want to measure year by year the result of the sales policy as compared to the general trend, we can proceed as follows:

(1) Determine the yearly percentage of American Tobacco Company sales as compared to total tobacco sales. We find the following percentages:

TABLE LX

AMERICAN TOBACCO COMPANY
SALES IN PERCENT OF TOTAL TOBACCO SALES

1934	16.2 percent	1941	16.2 percent
1935	15.3 "	1942	18.3 "
1936	15.0 "	1943	21.1 "
1937	14.4 "	1944	21.2 "
1938	14.9 "	1945	19.4 "
1939	14.8 "	1946	22.4 "
1940	15.2 "	1947	21.6 "

(2) Then represent graphically, year after year, the American Tobacco Company's share of the market (in percent of the total market). This is done in Figure 74.

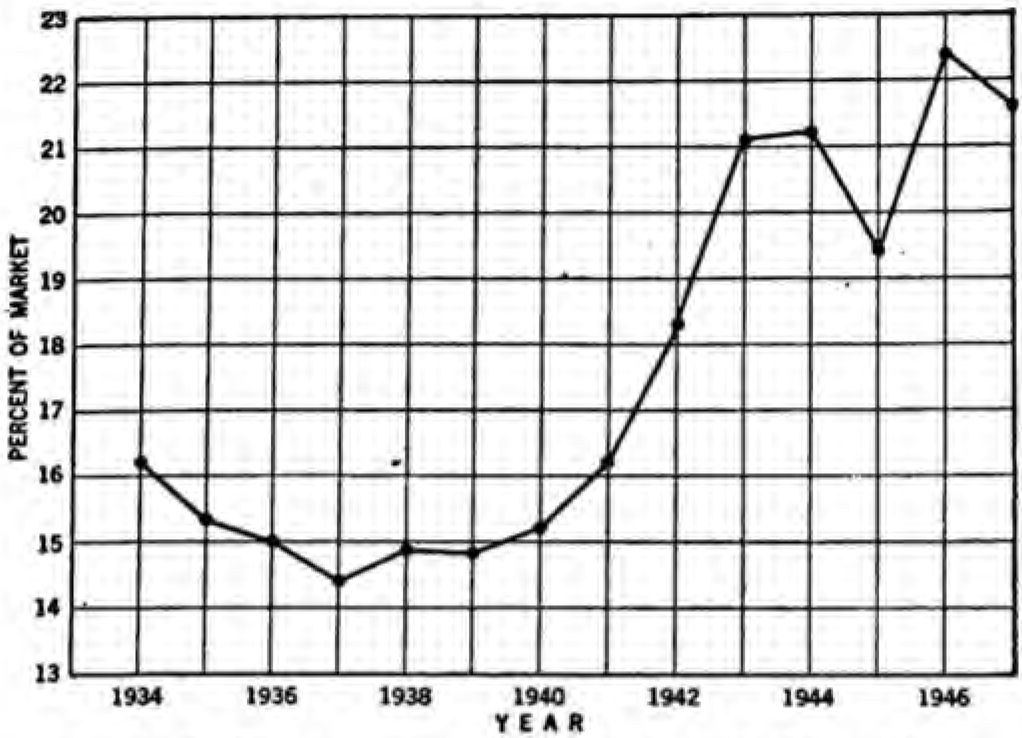

Figure 74. The American Tobacco Company's Share of the United States Tobacco Market, 1934–1946

We note:

(a) From 1934 to January 1, 1938, a descending trend
(b) After 1938, an ascending trend, first slowly ascending, then increasing its slope.

Such an analysis would give a scientific basis to a decision rendered on the disputed point. It shows that the stockholders' contention was justified for the period 1934–1938. After 1938, management made an obvious effort to improve its performance. By 1941, it had regained the ground previously lost, and after 1941 it performed remarkably well, as far as the sales figures are concerned.

The mere reading of the company's profit and loss statement does not reveal such facts.

It is interesting to note that 1938, which, according to this analysis, was a turning point in the company's life, was precisely the year during which the board appointed a new vice president in charge of advertising. His performance, later on, was highly praised in a letter of the president to the stockholders (February 1, 1940).

6. *Income brackets—available income*

a. General remarks. The whole previous analysis is based on the notion of *aggregate income.* Its usefulness is established by the existence of a definite trend of relationship of consumption expenditures to this aggregate income. But the limitations of this analysis are apparent, too. They result from the fact that the aggregate income is an aggregate of the incomes of widely different income groups, large, medium, and small.

Such a consideration is of little importance for the selling of a product like tobacco, for example. The market of the American Tobacco Company, just discussed, includes high-income, middle-income, and low-income customers as well. Very few people are so poor that they cannot afford to purchase cigarettes, and very rich people will also buy standard tobacco products.* The same is true for a few other products, such as bread or soft beverages, for instance.

For many products, however, and even for most of them, the manufacturer should be familiar with a too-little-known kind of income, which could be designated as the *available income.*†

A producer seeking a market is interested only in those customers who have incomes which are available for the purchase of his goods. Thus far, we have considered the income from an *objective* point of view. The national income, the personal income, the disposable income are objective. They are the same for all manufacturers, and for the whole population under consideration (the nation, the state, or any other geographical unit). The available income is the income that is *available to given individuals or families for the purchase of a given product.* This is a subjective notion. An example will illustrate.

Two families, A and B, have respective incomes of $25,000 and $2,500. Family B has obviously no income available for the purchase of a $4,000 car. But both families have some money available for the purchase of a five-cent bottle of a soft beverage. The manufacturer of $4,000 cars must know how many families have an income available for the purchase of his production, so that he can know how wide his potential market is. Obviously, the study of the available income is a

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* Low-income customers, however, may ration themselves, while high-income customers will not smoke indefinitely. Even for such products, therefore, a too great dispersion of incomes tends to reduce consumption.

† Since the first edition of this book was published and the above was stated, the notion of available income has received increased attention, as shown by the recent surveys and studies listed on pages 427–428.

very complex one but it is a necessary one. As the available income is a subjective notion, a special study is required for each product. This book can only outline a suggested approach to the problem. The first step is to become familiar with the distribution of income among the population.

b. Income brackets. The "income brackets" or the distribution of income in the United States according to the size of individual or family income has been carefully studied during the last few decades and has received increasing attention in recent years. The various studies made are based on statistical samplings. They have been conducted by somewhat different methods. In recent years, they have resulted in some difference of interpretation, especially with regard to the changes that have or have not occurred during the decade following World War II. Another source of discrepancy is the difference in terminology. For some surveys, a "capital gain" is an income; for others it is not. This results in substantial differentiation when it comes to an evaluation of high-income brackets, among which the trend has been in recent years to reduce the tax burden by submitting long-range incomes as capital gain in accordance with existing tax laws. Another

TABLE LXI

DISTRIBUTION OF SPENDING UNITS * AND MONEY INCOME RECEIVED BY INCOME GROUPS—1947 AND 1955

Annual Money Income before Taxes			Spending Units Cumulative				Total Money Income Cumulative	
	1955	1947	1955	1947	1955	1947	1955	1947
Under $1,000	11%	14%	11%	14%	1%	2%	1%	2%
$1,000-$1,999	12%	22%	23%	36%	4%	10%	5%	12%
$2,000-$2,999	13%	23%	36%	59%	7%	17%	12%	29%
$3,000-$3,999	14%	17%	50%	76%	10%	18%	22%	47%
$4,000-$4,999	14%	10%	64%	86%	13%	13%	35%	60%
$5,000-$7,499	22%	9%	86%	95%	28%	16%	63%	76%
$7,500-$9,999	8	5%	94	100%	14	24%	77	100%
$10,000 and over	6		100		23		100	
All income groups	100%	100%			100%	100%		
Median income † $2,530 in 1947; $4,650 in 1955								

Source: *Federal Reserve Bulletin.*

* The *spending unit* is defined as "all persons living in the same dwelling and belonging to the same family who pool their income to meet their major expenses."

† The median amount is that of the middle spending unit when all units are ranked by size of income.

source of distortion, which this time affects the low-income bracket, is the fact that there are substantial sources of income among them that are income in kind and therefore remain unrecorded as such (rent of farmhouses, food and fuel produced by farmers for own consumption, board and lodging received by farm workers and domestic servants, etc.). Discrepancies in estimates of income brackets may therefore result from the fact that such factors are or are not influencing the statistical sampling. Another factor which tends to create confusion is, of course, the changes in the value of the dollar, which were studied in the preceding chapter.

Despite differences which must therefore be expected, the results obtained by the various surveys reveal the same general pattern of distribution. They should thus be considered as confirming each other to a large extent. In any detailed study it would, however, be advisable to give attention to the various surveys available and to indicate to what extent the conclusions reached on the basis of data provided by any of them would be modified if another one had received preference.*

In this review of the current situation we will more specifically describe the survey conducted by the Federal Reserve Board and compare its findings for the year 1947 (survey conducted in 1948) with those for the year 1955 (survey conducted in 1956).

Table LXI gives the result of this survey, as far as the distributions of income for the years 1947 and 1955 are concerned.

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* See:

a. *For historical studies:*

1. "Size Distribution of Income since the Mid-Thirties" (with Adjustments for Change in the Value of the Dollar) by S. Goldsmith in *Review of Economics and Statistics*, February, 1954.

2. "Characteristics of the Low-Income Population," Joint Economic Committee, 84th Congress, 1st Session, 1955.

b. *For a discussion of the surveys available and of the methods followed:*

1. J. F. Dewhurst and Associates, *America's Needs and Resources: A New Survey.* New York, 1955, pp. 92*ff*.

2. Bureau of the Census, *Current Population Reports,* Series P. 60, No. 19, October, 1955.

c. *For periodically published data:*

1. U.S. Dept. of Commerce, Office of Business Economics, "Income Distribution" series.

2. U.S. Dept. of Commerce, Bureau of the Census, *Current Population Reports,* Series P. 60.

3. U.S. Treasury Dept., Internal Revenue Series, *Statistics of Income.*

4. Federal Reserve Board, *Annual Survey of Consumer Finances.*

If the spending units are ranked by size, their share of total income would be as shown by Table LXII.

TABLE LXII

SHARE OF TOTAL MONEY INCOME RECEIVED BY EACH TENTH OF THE NATION'S SPENDING UNITS, WHEN RANKED BY SIZE OF INCOME (1947 AND 1955)

Spending Units Ranked According to Size of Income	By Each Tenth		Cumulative		Income of Smallest Income Receiver in Group	
	1955	1947	1955	1947	1955	1947
Highest tenth	29%	33%	29%	33%	$8,440	$5,700
Second	16%	15%	45%	48%	6,500	4,200
Third	13%	12%	58%	60%	5,380	3,500
Fourth	11%	10%	69%	70%	4,640	3,000
Fifth	9%	9%	78%	79%	3,960	2,550
Sixth	8%	7%	86%	86%	3,240	2,100
Seventh	6%	6%	92%	92%	2,470	1,700
Eighth	4%	4%	96%	96%	1,650	1,200
Ninth	3%	3%	99%	99%	900	750
Lowest tenth	1%	1%	100%	100%	0	0
	100%	100%				

Source: *Federal Reserve Bulletin.*

For a clearer picture of the whole situation, a graphic representation will be found helpful. Figure 75 gives such a graphic representation of the income distribution in the form of a "Lorenz Curve." Figure 76 shows the income distribution in terms of annual money incomes. The latter figure reflects the fact that there has been an over-all increase of income during the period 1947–1955. Figure 75, however, clearly shows that the distribution of this increased income follows in 1955 a pattern almost identical with that of 1947.

This income distribution commands the selling price of products intended for mass consumption by the whole population, such, for instance, as most of the food products or the goods of current consumption sold in the popular ten-cent stores. Their selling price—and therefore their quality—must be adapted to the possibilities of a group of customers (the nation as a whole) whose median income is $4,650 for the spending units (and $2,570 in 1955 for the individuals).

At the same time, the fact that almost one half of the national income is earned by one fifth of the population gives to this one fifth

(the so-called "upper two tenths," earning more than $6,500) a very substantial economic weight. This accounts for the fact that a large part of the production of consumption goods (cars, radios, household appliances, etc.) is sold at a price that puts it obviously out of reach of the median income consumer.*

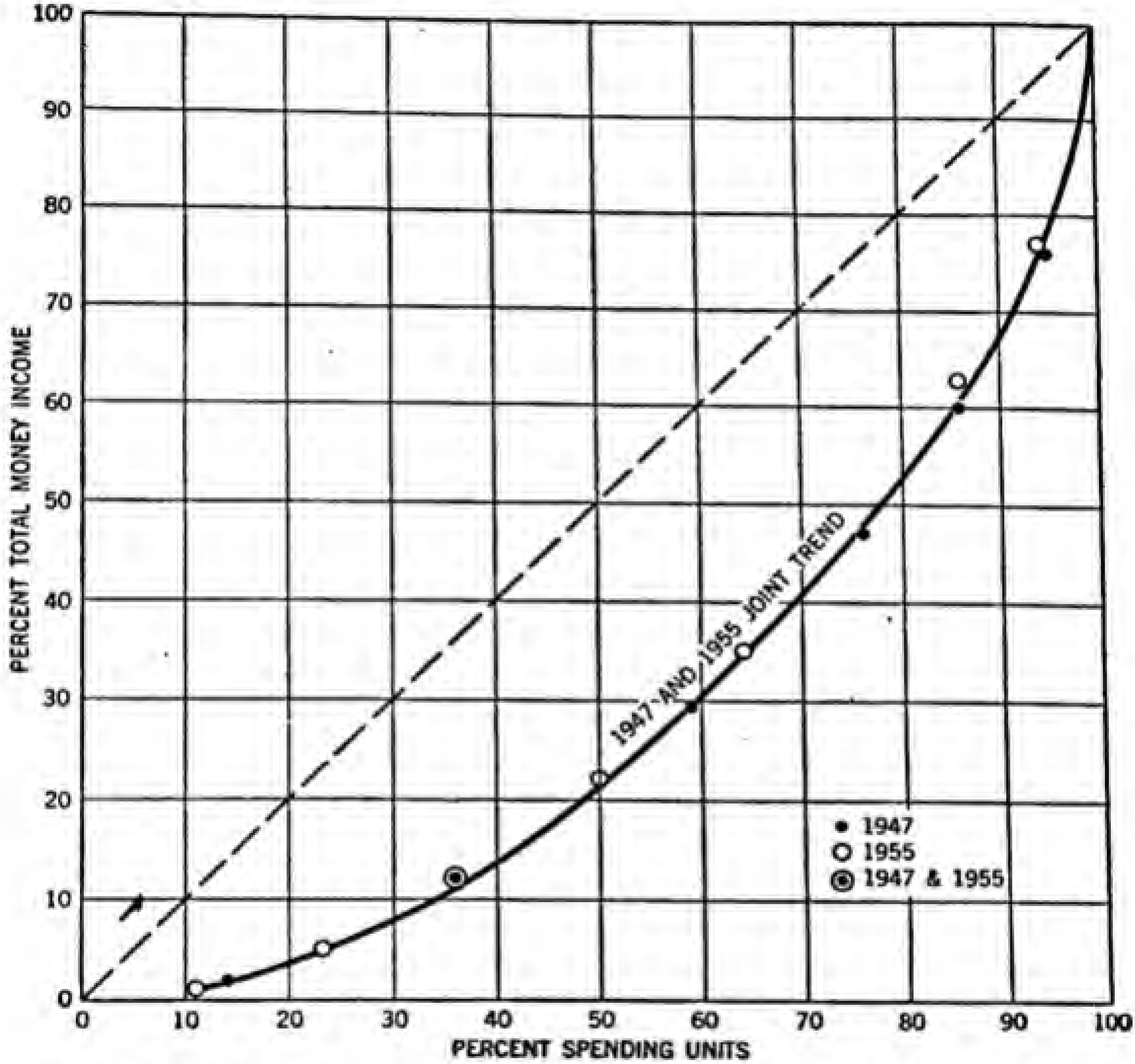

Figure 75. The Lorenz Curve of Income Distribution, United States, 1947 and 1955

It is sometimes difficult—but it is always vital—for a manufacturer to know in which income brackets his customers find themselves. Sometimes he will have to make his own survey, either directly or through specialized private organizations. Often he will find the required information in the surveys that are made and published by various public

* Unless the purchase is financed by savings or credits, as will be shown later in this chapter.

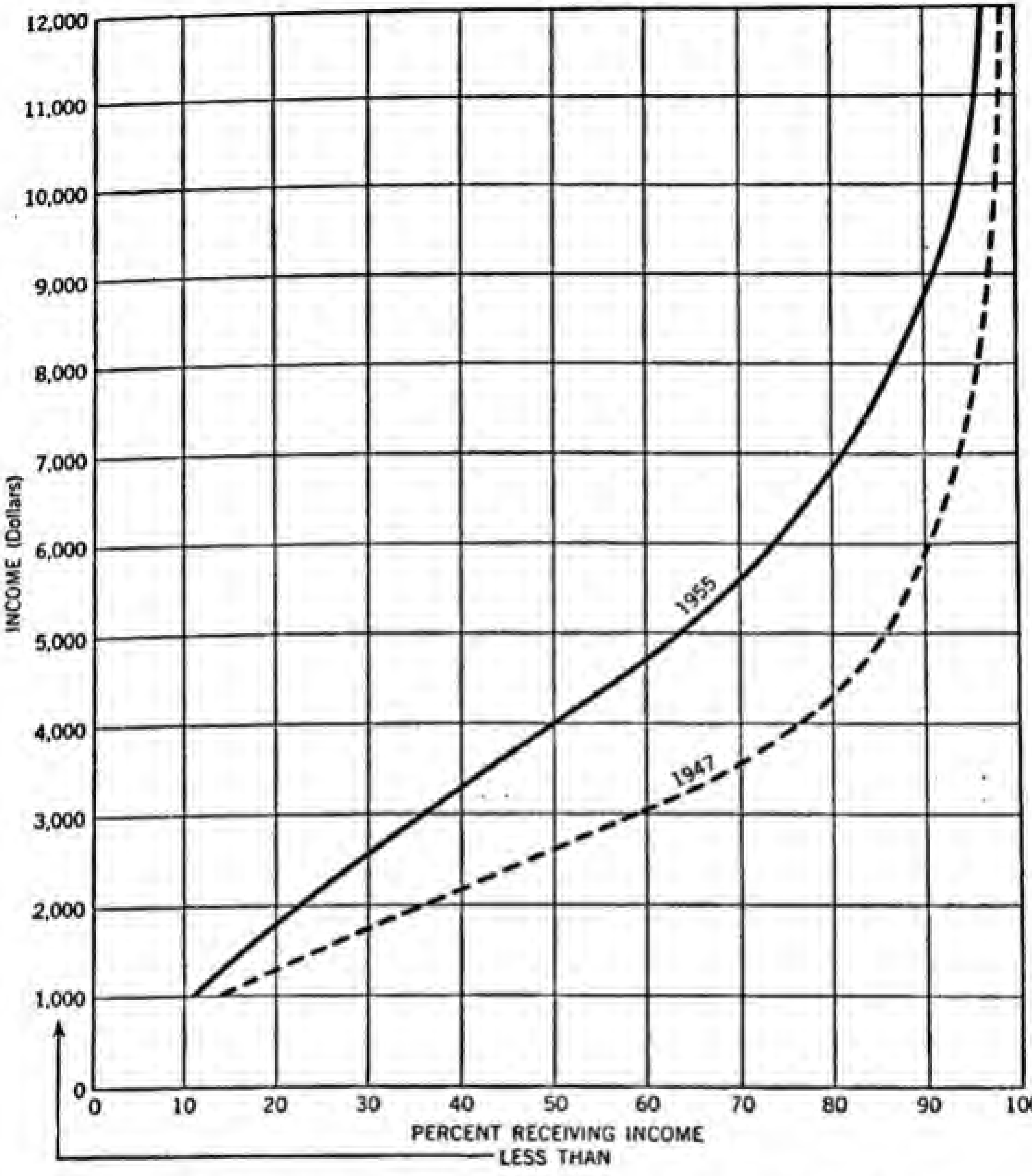

Figure 76. Income Distribution by Spending Units, United States, 1947 and 1955

agencies. Such will be the case if he is in a position to know some definite characteristics of most of his customers.

The Federal Reserve Board makes a yearly survey of the distribution of spending units income by occupational groups, the results of which are given in Table LXIII for the year 1955.*

* For another periodical survey of the same type, see: United States Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P. 60, "Consumer Income."

TABLE LXIII

DISTRIBUTION OF SPENDING UNITS WITHIN DIFFERENT OCCUPATIONAL GROUPS, BY SIZE OF INCOME, 1955

(Percent)

Annual Money Income before Taxes	Professional	Managerial	Skilled and Semi-skilled	Clerical and Sales Personnel	Unskilled and Service	Farm Operators	Self Employed
Under $1,000	2	—	2	2	14	19	2
$1,000-1,999	2	2	5	6	23	29	7
$2,000-2,999	3	2	11	15	23	15	6
$3,000-3,999	8	9	16	18	19	15	10
$4,000-4,999	12	15	22	15	11	10	10
$5,000-7,499	37	28	32	29	8	10	25
$7,500 and over	36	44	12	15	2	2	40
All Income Groups	100	100	100	100	100	100	100
Median Income	$6,250	$6,750	$4,660	$4,290	$2,520	$2,190	$6,000

Source: *Federal Reserve Bulletin.*

The income distribution for farm operators is not closely comparable with the distribution for other groups because of the large amount of non-money income that farmers produce for their own consumption.

Such a survey shows, for instance, that a manufacturer producing for customers engaged in managerial activities may expect them to have a $6,750 median income, while if his production is intended for unskilled workers, he cannot count upon a median income higher than $2,520. Such figures compare with the general median income of $4,650 previously indicated.*

c. Available income. After the manufacturer has obtained a reasonably accurate estimate of his customers' income, he will then try to determine with reasonable accuracy their *available income as far as his products are concerned.*

As already emphasized, the available income is a subjective evaluation. A family of four, living in a large city, with an annual income of $2,000, has certainly a portion of its income available for bread and

* See Table LXI, page 421.

a certain amount of clothing but, obviously, no available income for a new car, a washing machine, or an expensive radio.

The available income of this family, in regard to the purchase of bread or of a certain amount of clothing, is *not* the same as the available income of the *same family* in regard to the purchase of a car, a washing machine, or an expensive radio.

This is precisely what makes it difficult to determine the available income of a given group of customers for a given product. All the same, a fair estimate of his customers' available income is necessary to the businessman. In fact, he would not stay in business if he was not able to make such a fair estimate.

Many businesses base their market forecasts on feelings, rule of thumb, and hearsay. The main reason is that, until recently, they had no way of proceeding on a more scientific basis. The necessary information was just not available. The technique of the sample survey now in use to obtain information on consumer finances, for instance, is a development of relatively recent years.* It is normal that all businessmen are not yet aware of the exceptional opportunity for information offered by such new techniques. However, it is possible, today, in the United States, as probably in no other country in the world, for a businessman to gain a reasonable knowledge of his customers' income. This is the first step toward the determination of their *available income in regard to a given product*. The second step requires a reasonable knowledge of their expense budget.

Although the information published on this subject may not be as complete as that published concerning consumers' income, it can be extremely useful in many cases. Also, it is probable that the techniques now in use will be improved and that business of the future will make an increasing use of the statistical information on hand. The student in managerial economics will certainly profit greatly by becoming familiar with the various studies and surveys of the subject made in the past or being periodically conducted. He should also give serious attention to future developments in the field, which developments can be safely predicted.

Among the comprehensive studies and surveys now available, the following can be mentioned:

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* See: "Explanation of the Sampling Method" (*survey of consumer finances*) in *Federal Reserve Bulletin*, June, 1947; Churchman, Ackoff, and Wax, *Measurement of Consumer Interest*, University of Pennsylvania Press, 1947; and also: United States Bureau of the Census' monograph, "A Chapter in Population Sampling," Washington, D.C., 1948.

(1) The very comprehensive "Study of the Consumer Expenditures" in the United States, made in 1935–1936 by National Resources Committee.* This study, although made in the prewar years, remains a basic document on the question.

(2) The yearly "Survey of Consumer Finances" by the Board of Governors of the Federal Reserve System. In addition to the part devoted to the consumer income, which has been largely used in the previous discussion, this survey gives detailed and reliable information concerning consumers' expenditures and buying intentions.

(3) Such extensive research work as the "Study of Consumer Expenditures, Income and Savings" of the Wharton School of Finance and Commerce, University of Pennsylvania, 1956.

(4) Studies of the family budget. A very comprehensive study was undertaken after World War II by the United States Department of Labor.† It indicated that in Washington, D.C. (the highest cost city among the 34 surveyed), the city worker's family budget has to be $3,458 to enable him to provide "a list of goods and services that, according to the prevailing standards of the community, are considered essential . . . below which deficiencies exist in one or more aspects of family consumption." ‡

By comparing this estimate to the actual family income, as published by the Bureau of the Census,§ it was found that in 1947, in Washington, D.C., 38.8 percent of the families had an income of less than $3,499. This means that almost 40 percent of the families in Washington, D.C., could not live according to the minimum standard established by the Department of Labor.||

The problem is still a very actual one. It was described in these terms in the Report of the Joint Economic Committee on "A Program for the Low-income Population at Substandard Levels of Living," issued ten years later, in 1956: ¶

> There are no precise estimates of the proportion of our total population with substandard economic status—i.e., those whose total economic resources

* See also, National Resources Committee, *The Structure of the American Economy*, Part I (1939), p. 6; and Churchman, Ackoff, and Wax, *op. cit.*

† U.S. Department of Labor, Bureau of Statistics, *Monthly Labor Review*, February, 1948.

‡ *Ibid.*, p. 138.

§ Series P. 60, No. 4.

|| The proportion was slightly reduced (to about 30 percent) if one considered white families only.

¶ 84th Congress, 2nd Session, Joint Economic Committee, Report 1311, Washington, D.C., 1956, p. 2.

over long periods of time are not sufficient to provide an adequate level of living. The materials assembled by our staff, however, indicate that the size of this population at permanently depressed levels of living is substantial; one study made available to us, for example, puts the proportion as high as 20 percent of all urban families and individuals.

These further details were also made available:

Broken families, such as those headed by a woman because of the death of her husband or because of divorce or separation, are another economically disadvantaged group. The average income in 1952 of families headed by a woman was only $2,235. About 4 million children live in such families. *

It seems that in the years to come, the problem of low-income families is likely to receive increasing attention. It is typically a case where social, sentimental, and economic considerations rejoin each other. As aptly stated in the same report:

It may always be true that at any given time the economic resources of some families may temporarily fall below a level of adequacy. We have, as a nation, made considerable progress in lessening the hardships caused by temporary income loss through the expansion and continued application of sound insurance principles. Moreover, positive and constructive Federal programs directed toward maintaining a stable economy and full employment have reduced, in large measure, the number of families with temporary income losses due to lack of employment opportunities.

We are especially concerned, however, with the fact that millions of American families are today living at income levels permanently, not temporarily, depressed and which are below prevailing standards of adequacy. The low economic status of these families signifies that they are participating only fractionally in our economic life. They contribute little to our national productive effort; as consumers they are severely limited in the amount of goods and services they can buy.

The continuing prevalence of families and individuals with low economic status represents, in short, one of the greatest remaining challenges facing our domestic economy. We are convinced that with national income at peak levels and with relatively full employment, now is the time for a renewed and vigorous attack on the remaining problems of low-income groups.†

The general conclusion of this survey indicated that the problem of the low-income group is primarily one of education. It was recommended that attention be given to the improvement of educational facilities, which would "*break the cycle of self-perpetuation within the low-income group.*"

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* 84th Congress, 1st Session, Joint Economic Committee, "Characteristics of the Low-income Population," p. 53.

† *Ibid.*, Report 1311, p. 4.

B. CONSUMER CAPITAL

If a study of the customer's available income for a given product reveals that there is not a sufficient available income to pay its price, the manufacturer should endeavor to know if he has a chance to be paid by the customer's capital.

In fact, dissaving is a current procedure today for a large part of the population *—even for the purchase of non-durable goods, that should, in a healthy economy, be paid for from current income.

The manufacturer who counts upon his customers' savings for the financing of their purchases should be aware of the distribution of such savings according to their size and among the various groups of the population. The following tables (Tables LXIV, LXV, and LXVI) give him useful indications in this respect. (Source: *Federal Reserve Bulletin.*) †

TABLE LXIV
DISTRIBUTION OF SPENDING UNITS BY SIZE OF LIQUID ASSET HOLDINGS
(*Percent—1956*)

Amount of Liquid Assets Held		Cumulative
None	28%	28%
\$1-199	15	43
\$200-499	12	55
\$500-999	12	67
\$1,000-1,999	11	78
\$2,000-4,999	12	90
\$5,000-9,999	6	96
\$10,000 and more	4	100%
	100%	

Table LXIV reveals that more than a fourth of the spending units have no liquid assets at all; more than half, less than \$500 liquid assets; and more than three fourths, less than \$2,000. Table LXV shows that almost half the liquid assets are held by the spending units ranked in the upper two tenths income brackets.

* For a comprehensive study, see Goldsmith, Brady and Mendershausen, *A Study of Savings in the United States*, Princeton University Press, 1956 (especially Vol. III, pp. 182*ff*.). For a yearly survey, see *Federal Reserve Bulletin*.

† "Liquid assets" includes U.S. Government bonds, checking and savings accounts, excludes currency holdings.

TABLE LXV

PROPORTION OF LIQUID ASSETS HELD BY EACH TENTH OF THE NATION'S SPENDING UNITS, WHEN RANKED BY SIZE OF INCOME

(*Percent—1956*)

	By Each Tenth	Cumulative
Highest tenth	33%	33%
Second	13	46
Third	13	59
Fourth	8	67
Fifth	6	73
Sixth	7	80
Seventh	5	85
Eighth	5	90
Ninth	6	96
Lowest tenth	4	100%
	100%	

C. CONSUMER CREDIT

The previous analysis of consumer income (national income, personal income, disposable income, available income) and of consumer capital clearly shows that:

1. A high proportion of consumers have an income that is just sufficient or sometimes not sufficient for the payment of expenses necessary for an adequate standard of living.

2. The consumers whose incomes are such that it leaves them little or no available income for non-essential purposes are precisely those whose liquid assets are non-existent or not significant.

TABLE LXVI

SIZE OF LIQUID ASSET HOLDINGS WITHIN DIFFERENT OCCUPATIONAL GROUPS

(*Percent—1956*)

Amounts of Liquid Assets Held	Professional	Skilled and Semi-skilled	Clerical and Sales Personnel	Unskilled
None	5	30	14	52
$1-499	28	32	36	28
$500-1,999	31	21	29	13
$2,000-4,999	20	11	14	5
$5,000 and over	16	6	7	2
	100	100	100	100

The conclusion to be drawn is that, as things are today, consumer credit is a necessity for the consumer, and for the producer as well, if the former is to get the goods and services he needs and the latter to attain the minimum level of sales under which he cannot break even.

At the same time, it should be fully realized that extensive consumer credit are a very serious factor in inflation. They are also a potential danger for the future if consumers' purchasing power is not finally adapted to consumers' purchases, as was shown by the 1929 experience of excessive consumer credits.

The difficulty in solving such a dilemma explains why there has been lately so much controversy and uncertainty about consumer credit. The regulation which, during the war, severely restricted consumer credits (so-called Regulation W) ended soon after the war. It was reinstated in a milder form in the summer of 1948, but the statutory authority expired in 1952 and was not renewed, although it is a possibility that future regulation may be needed to control a potentially dangerous situation. An indirect but apparently effective control of the expansion of consumer credit has resulted from the periodically recurring restrictive policies of the Federal Reserve Board, policies which have been criticized in some business circles.*

The total consumer credit (installment and non-installment) reached \$35.5 billion in January, 1956. This represents 13 percent of the disposable income for 1955 (\$270.5 billion). It is by far the highest ratio ever reached in our economy.

Much has been said in favor of consumer credit. From the point of view of the national economy, it is a fact that a large proportion of retail sales is financed by consumer credit. This is especially true for automobile sales, among others. In fact, as things are today, business cannot exist without some sort of consumer credit. From a family-budget point of view, consumer credit makes it possible for the consumers to establish their standard of living at a high level at an early time in their life. It provides a highly desirable financing of family life.

What has been said against consumer credit is actually directed against the abuses of credit rather than against its reasonable use. Although precise data are not available, it seems that in recent years many families have gone into debt that is too heavy in relation to their

* The following recommendation was made in the January, 1956, Economic Report of the President (p. 94): "Although present conditions do not call for the use of . . . authority to regulate the terms of installment credit, this is a good time for the Congress and the executive branch to study the problem . . ."

present and probable future income. It is also a fact that consumer credit has been pushed in fields where it seems hardly justified: for instance, as a means of financing vacation trips that are not commensurate with the consumer's income.

The point has been made that, although delinquency and loss records remain low, debtors have been in many cases pyramiding their debts to pay off old ones.* Such abuses are obviously a threat to both family life and the national economy.

Actually, in 1956, it was found that 63 percent of all spending units reported some debt other than charge accounts. Most of the personal debt outstanding was installment debt. †

From the point of view of business management, this means the necessity of considering a relatively liberal credit policy while at the same time realizing its possible dangers. Conservative managements endeavor to solve the dilemma by transferring their risk to a specialized organization, even at a substantial cost. In fact, many businesses prefer to leave the financing of their installment sales to specialized companies, such as the sales finance companies.

The charge account, this other form of consumer credit, is usually a risk of the business itself. Many businesses, however, do transfer the financial risk involved to specialized agencies by taking credit insurance. This method regains, periodically, its popularity, and will probably be looked on with more and more favor by business if the present uncertainty should increase.

Credit insurance is a form of insurance that covers accounts receivable. More widespread in textiles and apparel than in other industries, such protection is available to manufacturers, wholesalers, and jobbers in almost every field.

However, it is by necessity restricted to businesses whose loss record is fairly normal. If debt losses are exceptionally low, it is not worth paying the premium; if they are exceptionally high, the insurance company may well reject the application. Losses are never covered in their entirety. When an account fails, the insurance company will normally deduct a certain percentage from the unpaid purchase price. Credit insurance, however, enables the manufacturer to be more liberal, to some extent, in granting credit. This may be of decisive importance in times when competition is strong. It is also a good protection against losses due to rapid and unforeseeable changes in gen-

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* See American Institute of Management, *Bulletin No. 5*, Vol. VI, August, 1956.

† *Federal Reserve Bulletin*, July, 1956.

eral economic conditions. Finally, it may enable a manufacturer to benefit indirectly from the credit information of the insurance companies; the refusal by a company, after investigation, to underwrite insurance on an account will, for example, be considered as a reliable warning.

GENERAL CONCLUSION

As it was pointed out at the beginning of this chapter, a discussion of the effective demand, and especially a discussion of the purchasing power of the population, is, of necessity, dominated by considerations which change from day to day. The situation will, no doubt, have changed very substantially between the time this book is being written and the time it will be read and used.

The reader of the future will, indeed, be interested in the situation of his own day. To be really useful to him, the reading of this chapter should not be attempted without the assembling of new data. The extensive references of the preceding pages should greatly facilitate the necessary research work.

However, in the discussion of effective demand and of its two elements, the population and the purchasing power, permanent principles are involved, beyond the changing appearance of statistical data and yearly performances.

Effective demand is the support and the justification of production. They are bound to each other. The more so because every individual living in a modern country is at the same time a producer and a consumer. The problem of a prosperous economy in such conditions is neither to adjust the effective demand to production nor to adjust production to effective demand. It is rather to integrate both of them in a well-balanced "national plant."

For almost a century, a continuous increase in population provided such a dynamic economy that the necessity of integration was not always fully realized. Today, although it is still on the increase, the population is no longer increasing at a comparable rate. The factor "purchasing power" takes its full importance. A real effort toward self-integration by business is needed.

We all support and should support great technological research. But we have fallen short in economic research.

For research in technology hundreds of millions of dollars have been spent by industry and, more recently, by government. Compared with that, pathetic amounts have been brought to the support of research that will help build a society to use that technology for the general welfare, to ad-

minister that technology wisely. The research going on in the principles of administration, in the understanding of our economic and social environment, and in the field of human relations is today tragically small.

There is need for much more—and more effective—economic research. To be of the highest value, it has to be independent, skillful, and most of all, honest—honest in its search for objective findings, not developed to prove a point. . . .

Usually some label of academic calm or ivied walls or ivory towers is put on those who work in universities. I sometimes think there are today more ivory towers in the business community than in the universities. Far too many businessmen have secluded themselves with their own groups without opening their minds to what is happening around, without appreciating the social and political and economic responsibilities of business leaders.

Just conducting research does not finish the job. To achieve the results sought, research findings and recommendations must reach and be understood by every group in America—and especially by the men and women who carry on the business enterprises of this country.*

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* Donald Kirk David, Dean, Graduate School of Business Administration, Harvard University, addressing the Board of Trustees, Committee for Economic Development, July 12, 1946.

XVI

INDUSTRIAL EXPANSION

CONCLUSION

THE PROBABILITIES of future production in all lines of manufacture such as automobiles, radios, refrigerators, locomotives, and shoes, to mention a few, are of interest not only to those who manufacture the final product but also to those thousands of manufacturers who supply the materials and component parts of the final product and to those whose own products are competing with it.

The market for leather shoes, for example, is also the market for the tanner and the manufacturer of rubber heels. The growth in demand for canvas and rubber-soled shoes is a matter of concern for the tanner of leather and a matter of interest to the producer of rubber goods. The builder of steam locomotives who expands his plant in anticipation of a future demand for railroad rehabilitation in which larger and faster trains are contemplated, is confronted with the rising demand for diesel-powered locomotives. The manufacturer who has built up a profitable but small- or medium-sized business is sud-

denly confronted with competition from a large and powerful company which has entered the field. Last, but certainly not least, the production of every manufacturer, large, small, or middle-sized, depends upon the situation prevailing in the national economy.

In recent years, government purchases and especially those related to national security have become an important factor in the national economy. The national security purchases * amounted to $41.2 billion in 1955, i.e., as much as 16 percent of the total personal consumption expenditures, which amounted to $254.0 billion for the same year. These $41.2 billion represented as much as 68 percent of the gross private domestic investment (including industrial plant construction), which amounted to $60.5 billion for the same year. Such government purchases are obviously subject to rapid and hardly predictable changes related to changes in the international situation and governmental policies.

In view of this even very curtailed statement of the conditions sometimes confronting the manufacturer, particularly one who operates a small- or medium-sized business, what can be stated about the problem of industrial expansion which will be helpful to such a manufacturer in planning the future course of his business?

It appears that the future market for the products of any manufacturer is conditioned by three major external circumstances which are:

1. The activity of scientific research and development in the materials, processes, and products with which the manufacturer is concerned
2. The strength of the competitive market
3. The growth in use of the products manufactured.

Of course, if the internal circumstances of the business in the matter of its organization, management, and controls are faulty, the future market of the business is in jeopardy no matter what the external circumstances may be.

With respect to the three external circumstances which may affect the future market of any business, the following observations are of interest.

I. THE INFLUENCE OF RESEARCH

The increasing activity in all the arts, sciences, and technologies seriously challenges the stability of industry in the matter of materials

* See: *Survey of Current Business*, National Income Number, 1956, Table 2.

and processes used and products marketed. Scientific research is a constant hazard to present invested capital while at the same time it develops opportunities for the investment of the capital of the future.

Many metal products of yesterday, for example, which were formed by casting, forging, or stamping, today are molded from plastics. Many equipment items of metal manufacture of former years are now replaced by molding presses or have been redesigned for a more economical production of metal parts. The illustrations of the consequences of scientific research in the economic obsolescence of invested capital and in creating demands for new machinery and plants requiring new capital investments are almost endless. It is not our purpose to recount even a small percentage of them. Our interest is to indicate ways and means by which the manufacturer of today may deal intelligently with this problem as he plans for the future development of his business. Very large companies maintain research scientists and development engineers whose business it is to improve materials, machinery, and processes for the purpose of putting new products on the market or reducing the cost of manufacture of present products of improved quality. The small- and medium-sized manufacturers usually cannot afford to equip and operate research and development laboratories and hence are often under constant threat of economic obsolescence of their present capital investment and the need for new capital for re-equipment purposes. This does not mean to state that all the improvements in the sciences and technologies of manufacture originate only with the larger companies nor that the larger companies are not under threat of the economic obsolescence of their own equipment. This is far from the truth. It is maintained, however, that the hazards are greater for the small- and medium-sized manufacturing companies and their ways and means for meeting the situation are somewhat different.*

What ways and means are available to the smaller companies for meeting the problems which research poses? Experience has shown that the following policies have been effective:

a. At least one officer or executive in high position should be chosen for his understanding of the importance of scientific and technological developments related to the business.

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* For a comprehensive and truly scientific study of the subject, see: "Report of the Chairman of the Special Committee To Study Problems of American Small Business," United States Senate, January 2, 1947. In recent years, the matter has become a rather controversial issue. See, for instance: "Report of the Joint Economic Committee," 84th Congress, Report No. 1606, pp. 18*ff*., Washington, D.C., 1956.

b. An industrial scientist * should be on the staff of the company in full time service or be available for periodic consultation on recent scientific developments which may affect any part of the future of the business.

c. Scientific and technical reporting organizations, such as *Science Abstracts* and the *Engineering Index,* should be made use of; and those developments reported which may have a bearing on the company's products or processes and the materials it uses should be interpreted in relation to the company's future plans.

d. Appropriate budget provisions should be made for experimental developments which current scientific trends may indicate will be fruitful.

e. Appropriate and adequate reserves should be set up to assure the capital needed for new equipment to replace that which is becoming obsolete and which should be retired. The expanding use of automatized equipment tends to accelerate the rate of obsolescence of existing equipment and is therefore giving increasing importance to this last consideration.

II. THE COMPETITIVE MARKET

The economic policies of small- and medium-sized manufacturing businesses with respect of the competition offered by the larger and more powerful companies are not easily formulated because of the varying nature of such competition. As a general rule, the following matters are to be taken into account:

A. *The economy of location and the limits of growth appropriate thereto.* The meat packing industry provides a good illustration on this point. In this industry the cost of material (cattle, hogs, and sheep, on the hoof) is a very large factor in the cost of the final product, as much as 80 percent in some cases. This, together with freight charges on the delivery of meat to the consumer makes it possible for small abattoirs to do a profitable business supplying the local markets. Cement block plants, garment factories, laundries, bakeries, machine shops, lumber mills, and a host of other industries may be favorably located as to markets and raw materials supply, so as to meet successfully the competition of larger companies not so favorably situated as to local markets and sources of supply. The policy of industrial expansion by such companies should be largely influenced by the growth in popula-

* The industrial scientist is of course one who understands also the scientific aspects of industrial organization and management.

tion and the purchasing power of the community served, as set forth in the preceding chapter. The program of capital investment in such businesses should be based on a policy of economy in production rather than an increase in size for the purpose of serving customers beyond the bounds within which the economic advantage of the business lies.

B. Federal legislation. Among the important external circumstances which may affect the competitive market and thus influence for good or for ill the future markets of any company are the trends in court decisions and federal legislation in the regulation of business practices. Such decisions may result in an opportunity for some companies to expand their markets while other companies will be adversely affected. The policy of expansion of any company should be reviewed with reference to the trend in government policy which may affect the markets it now serves.

C. Trend toward consolidation and merger. In recent years there has been a definite increase in such a trend. The fact is that there are distinct advantages in operating a large business. Marketing operations and research and development efforts, to mention only these two among many other activities, are more economical when they are supported by a large volume of sales. Financing of the business is also much easier for a large organization. It is not possible, as this edition is being prepared, to foresee what the future developments will be, but it seems likely that in the future some decisive steps will be taken in this respect. Either the small and middle-sized business will lose more and more of its relative position in the national economy or some effective measure will help in revitalizing it. Among the proposals that have been made, it can be mentioned that it has been suggested that trade associations might help in developing cooperative research among their members (market research, for instance). Such efforts however have often been prevented by the present anti-trust laws. The matter is likely to receive increased attention in the years to come. In fact, congressional investigations of these problems have been periodically conducted.*

III. GROWTH IN THE USE OF PRODUCTS MANUFACTURED

Individual businesses may either expand their markets or have to retrench in the face of competition, but the sum total of the annual

* For a study of some of these problems see J. Fred Weston, *The Role of Mergers in the Growth of Large Firms*, University of California Press, 1953.

increments of expansion of all companies in a given industry seems to be conditioned by a characteristic phenomenon of growth which we will now explain.*

When one plots the height or size attained day by day by a plant, such as the *citrus lemon* as shown in Figure 77, it is found to follow a definite pattern. The characteristics of this pattern are that in the earlier period of growth the change in size is very gradual; in the middle period there is a marked increase in the rate of development; and then there follows a period of maturity marked by a decrease in the *rate* of expansion or growth and a subsequent tendency to stabilize.

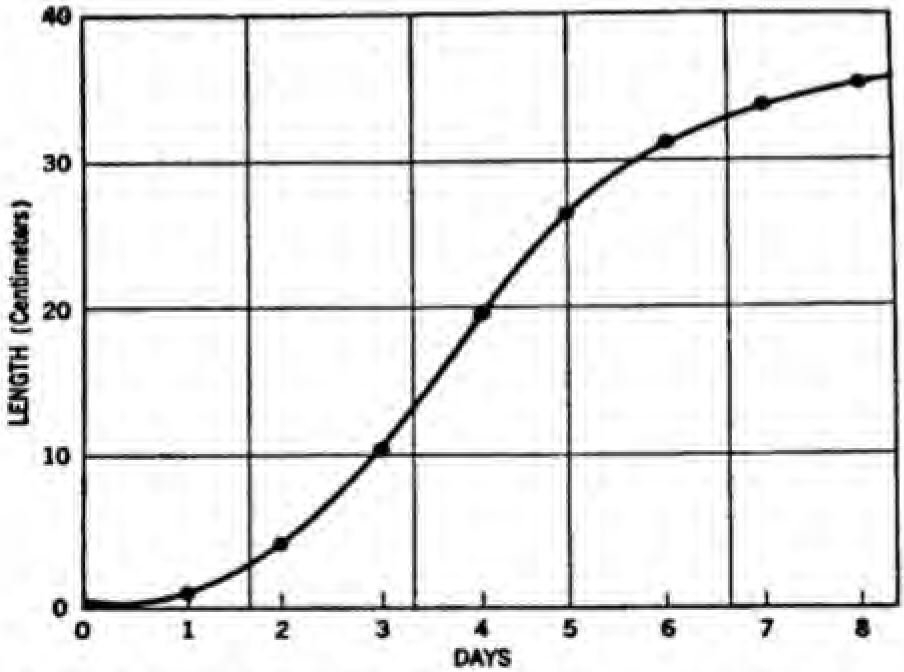

Figure 77. The Growth of a Lemon Shoot in Length

Interestingly enough, when one plots the development of the population of a given country or the development of an industry, such as the automotive (as measured by motor vehicle registration) or the railroad (as measured by total mileage operated), it is found that these also tend to grow according to the same pattern as shown in Figure 78. The growth is not always regular in the sense that in each succeeding year there is an increase in production. In the case of automobile production, for example, the period from 1907 to 1929, showing a consistent trend in pattern, was characterized by a series of periodic

* For a study of the prospects of economic growth see, among others: *Potential Economic Growth of the United States during the Next Decade*, Joint Economic Committee, Washington, D.C., 1954.

recessions, as shown in Figure 79. But the main pattern of growth was followed. What causes bring about this growth pattern for populations, plants, and industries? In the matter of population and plants there are certain biological factors which condition growth that need not detain us in our studies. In the matter of industrial production the following observations may be of interest. The earliest models of automobiles, radios, and household refrigerators, to mention a few more recent types

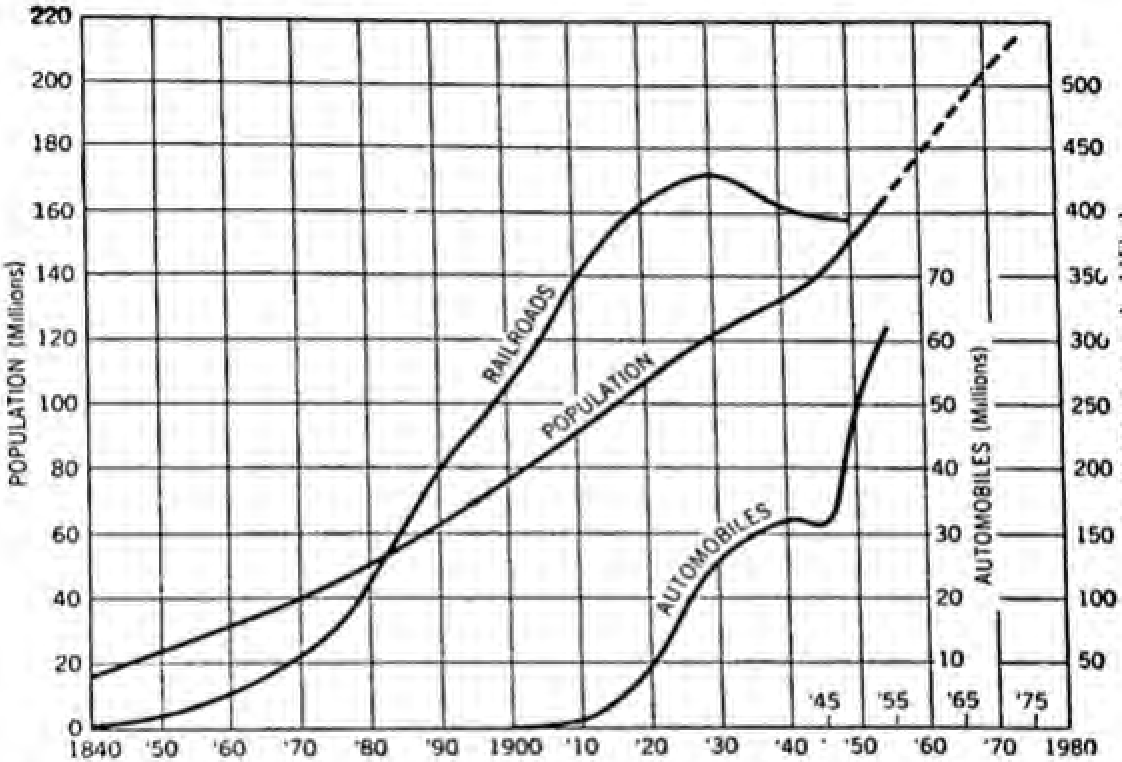

Figure 78. The Growth of Population, Railroads, and Automobiles in the United States, 1840–1955

of products, were rather crude affairs, produced at costs which limited the number of possible purchasers and furthermore were not among the conscious needs of the public. The earlier periods of these industries were marked by a rather gradual increase in annual production. With improvement in quality of product, and the development of more economical methods of manufacture, public acceptance was rapidly gained and the market area was increased by lower pricing. During this period, the profits made became attractive, investment capital flowed to the industry and rapid industrial expansion took place. The later phases of the period of industrial expansion are the most critical for reasons which are not far to seek. In the expanding years of an industry there are two classes of customers, those who are buying this type of

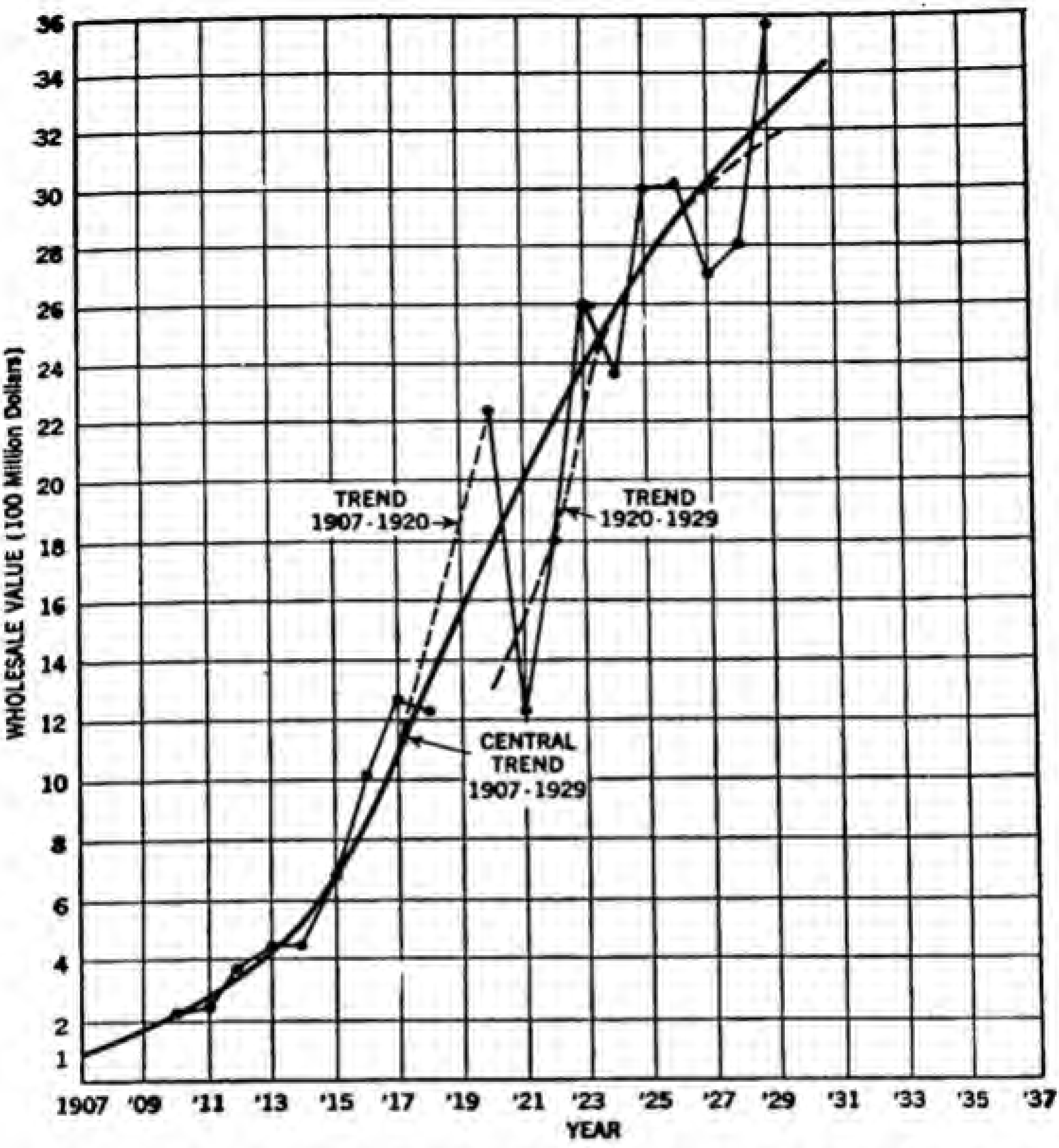

Figure 79. Growth of Automobile Factory Sales, United States, 1907–1929

product for the first time and those who are buying for replacement. Accordingly, the composition of the curve of annual production during this period is as shown in Figure 80. In time, the market tends to become saturated, the number of new customers becomes a smaller portion of the total, and the production for replacement tends to dominate. In a few years after this period, the annual production to supply new customers becomes less and less while the production for replacement continues to rise, as shown in Figure 81. Total production may therefore decline until such time as the replacement market dominates and total production rises again and becomes stabilized at a trend corre-

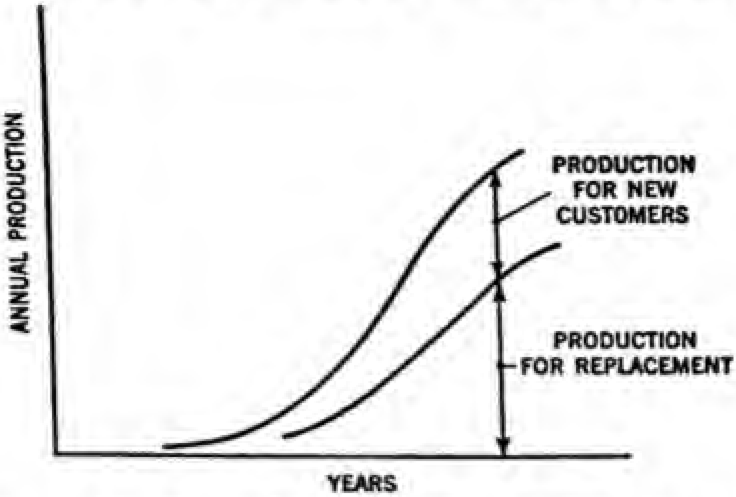

Figure 80. General Pattern of Annual Production of an Industry from Its Inception to Maturity

sponding to the growth in population. This situation is illustrated in Figure 82, which shows the growth of the automobile passenger car production in the United States from 1900 to 1955.

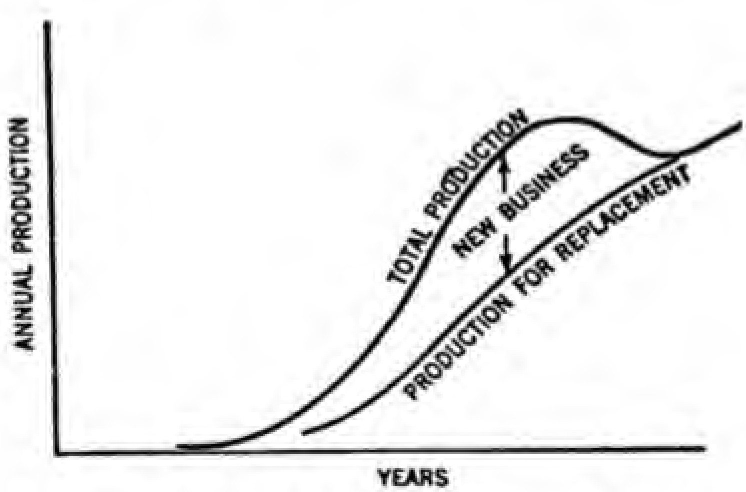

Figure 81. General Pattern of Annual Production of an Industry Particularly during Post-maturity

IV. THE INTRODUCTION OF STANDARDIZATION

The relation of industrial expansion to standardization has been very clearly shown by Dr. John Gaillard, formerly of the American Standards Association, and lecturer in the Department of Industrial Engineering at Columbia University, in his book, *Industrial Standardization*, as follows:

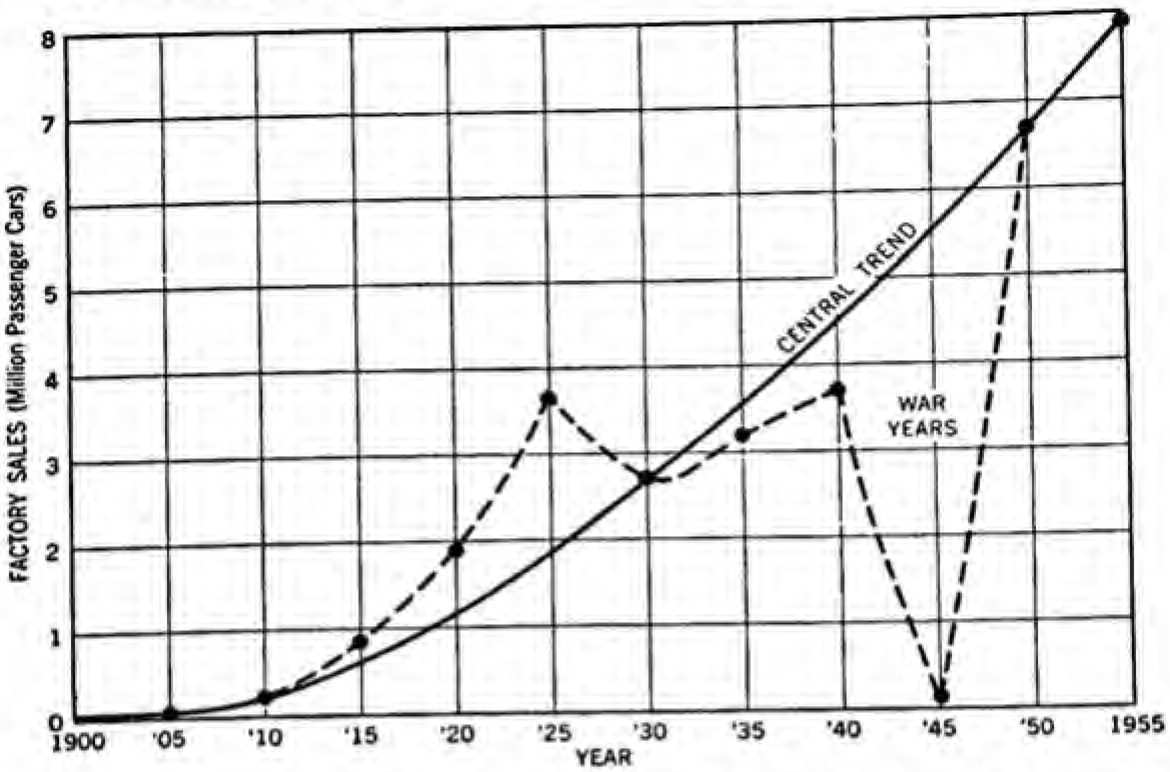

Figure 82. Factory Sales of Passenger Cars with Pattern of Trend, United States, 1900–1955

PROGRESS-TIME CURVE

Industrial progress due to new basic ideas (discoveries and inventions) plotted against time is represented by a continuously rising curve. The practical application of such basic ideas cannot follow such a curve. The development of each of them into the regular manufacture of a product or some other industrial activity requires time for building up the necessary machinery, figuratively, and in most cases literally, speaking. The best that can be attained is the approximation of the progress-time curve by a broken line. The horizontal parts of this line represent levels on which practice will be based during successive periods of time, independent of the rise made in the meantime by the progress curve. The vertical parts represent the shifts from each level to the next one. The graph in Figure 83 representing the development of a manufactured product * from the moment of its basic conception will illustrate this point. This development may be divided into three main phases. The first phase begins with the conception of a basic idea (a), which may be the result of invention or discovery. For a long period of time this basic idea may remain unsuitable for practical application because certain indispensable elements are still lacking. There may be a gap

* The curve representing the development of a composite product may be considered as resulting from the combination of similar curves applying to its elements which at a particular time may or may not be in the same phase of development.

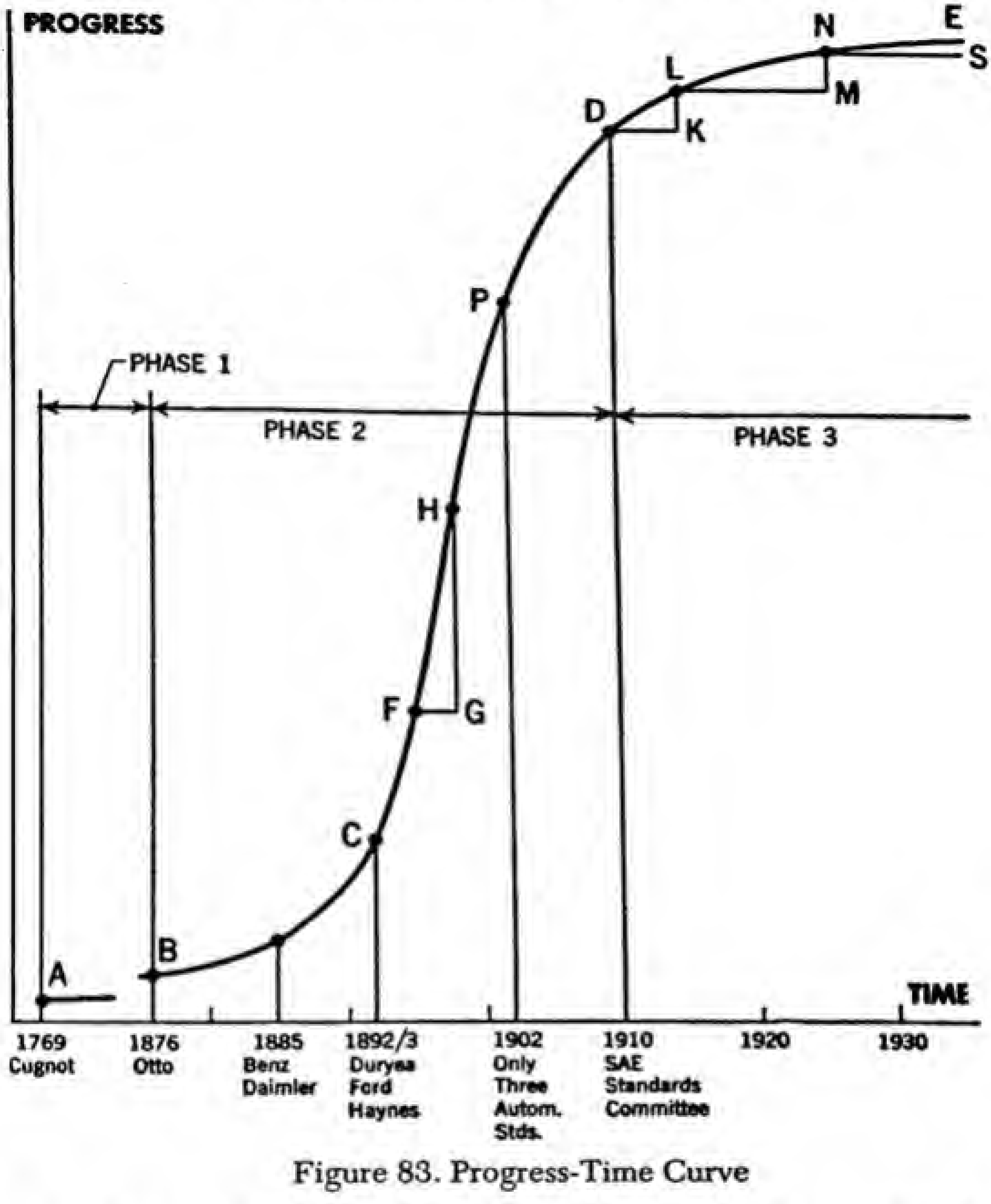

Figure 83. Progress-Time Curve

in the technical solution, or the technical solution may be complete but still too expensive for economic application. In both cases the world has to wait for one, or perhaps further inventions or discoveries.* Once the chain of elements required for the practical application has been completed, the basic idea becomes the beginning of an actual industrial development (b).

* The basic form of the present airplane (monoplane) was known to be suitable for mechanical flight about ninety years ago. In 1842 Stringfellow built a model driven by two propellers which was the first to make a flight (Encyclopedia Britannica, 14th Edition, Vol. 1, page 243). However, the airplane as a means of transportation had to wait for the development of an engine with a high enough power-to-weight ratio.

This is also the end of the first main phase A-B which might be called the "latent" phase.

From the point B on, the rate of progress will increase. At first, many problems of secondary importance have still to be solved * but the product is being manufactured and tried out in practice, be it still in very small numbers (stage B-C). At C the product has found a market, and manufacture is started in greater volume. Mutual induction between the efforts of industry to perfect the product and the results of practical experience gained with its use cause a steep rise of the progress curve from then on. Improvements follow each other in quick succession. The entire second main phase B-D might be called the "development" phase whose early portion B-C still has an entirely experimental character. During it, the product acquires a definite form as to its essential features.

From D on, only minor improvements are made.† Accordingly, the progress curve flattens out and approaches the horizontal direction asymptotically. This third main phase D-E might be called the "saturation" phase.‡ In general, it is not possible to determine exactly the point where the second phase changes over into the third. (Contrasting herewith, the transition from the first phase to the second is often quite distinct.) The third phase may last until a further basic improvement causes a new rise in the progress curve, or until the manufacture of the product is abandoned because the latter is superseded by a competitive one.

A progress-time curve of the kind described cannot be recorded in an exact manner, as it is impossible to assign a definite progress rating to each development causing a rise in the curve.§ It is possible, however, to determine its general shape on the basis of the considerations mentioned above. This is sufficient for our present purpose, namely to determine that point of the curve where industrial standardization may successfully be started. In practice the decision whether this point has been reached must be taken on the basis of the conditions observed to exist in each individual case. This is due not only to the fact that the progress cannot be rated in an exact manner, but also to the circumstance that the state of the art is only one among several factors influencing a program of standardization. Business policies of interested groups may delay the undertaking of standardization work well beyond the point where it becomes feasible in so far as technical progress is concerned.

The progress curve and the temporary levels or standards show at a glance what it means to have no standards at all, as well as the consequences of adhering to a standard for an unduly long period of time. If there are

* For example, the ignition and the carburetion systems of the gasoline engine, in its early days.

† For example, the bicycle in Europe during the last 30 years.

‡ The "saturation" is meant to apply to the progress in the art, and not to the market of the product.

§ In the evolution of the automobile industry, for example, we may single out the several steps leading up to the present type of gasoline engine; the application of interchangeable manufacture and continuous flow production; the development of special machine tools and of alloy steels; and the results of the research work on fuel problems carried out during recent years.

no standards at all, the progress curve will dictate continuous changes, thus preventing the full development of any particular form of the product. Adhering to a standard too long means that the gap between the progress curve and the level of the standard is allowed to become too wide. This situation will make the adjustment to the progress curve, once it must be made, extremely difficult. Also, the delay suffered in making this adjustment may result in a permanent loss of business through obsolescence of the product or through its being overtaken by a competitive product.

WHEN STANDARDIZATION CAN BEGIN

The graph in Figure 83 shows that standardization cannot be applied before the point D of the progress curve, the beginning of the third phase, has been reached.* During the first phase A-B, there is not yet any question of an industrial development, properly speaking. This is true even though a considerable amount of research data on basic facts may have been collected by the industry concerned. The second phase B-D is at first an experimental one. Its part C-D is characterized by rapid development involving frequent changes and considerable improvements of a more or less fundamental nature. If a standard were set up during this phase, say at F, revision would become necessary shortly afterward, say at G. No coordination, the second function of standardization, can be started on the basis of a level of conditions which itself remains stable for only a relatively short period of time (F-G). When the beginning D of the third phase has been reached, a large market has been secured for the product. The rate of the latter's improvement, at least in respect to essentials, has slowed down. Agreement has been reached, explicitly or implicitly, on the type, the performance requirements, and in many cases even on the main dimensions that are most desirable for the product with a view to its practical use; but, due to lack of coordination of such agreement, no definite and general uniformity exists as yet. However, conditions are now favorable for the successful undertaking of this coordination. If D is the point where it is started, this means that industrial practice will temporarily follow the horizontal line D-K instead of the progress curve D E. In the meantime, basic progress continues to move along this curve. The increasing distance between the latter and the level of the standard D-K creates a growing "pull" which tries to force industry off the adopted level D-K, so that it may adopt the latest improvements. As long as the benefits derived from the existing standardization plan still exceed those to be gained by changing over to the new practice, the standard D-K will hold its own. As soon as the stability of the standard is overcome, a new standard, say L-M, will be set up as a revision. Provision must therefore be made, in setting up the original standard, to permit such a change to occur without undue hardship when the "pull" toward improved practice becomes strong. Else the result will be that industry abandons the old standard in its actual practice. This clearly indicates that there is a fundamental danger of

* It may be possible to standardize certain components of a product before standardization of the entire product can be undertaken. The individual curves of these components have then reached their respective points D without this being the case for the composite curve.

overstabilization in standardization work which may be due to different causes. . . .*

When a new standard L-M has been established, the same phenomenon is repeated. The graph shows that if the "pull" required for a change in the standard remains the same—being equai to K-L, in terms of progress—the standard L-M will remain valid for a longer period of time than the standard D-K. The same statement will be true for each subsequent revision of the standard, such as N-S. Finally, the time comes when the progress curve runs so closely to the latest standard level that no tendency to depart from this level develops. In this way, a "stabilization of the standard" may ultimately result, unless special causes, such as a change in the demands of the buying public, upset this condition.

CONCLUSION

To summarize the methods that have been presented in this book, it can be said that they are essentially related to the study of three fundamental relationships:

FIRST *The cost to sales relationship,* which is the key to profit and is measured for each business by the linear trend of the break-even chart. This relationship lends itself to comparatively precise measurements.

SECOND *The sales to national income relationship* for which measurements are less precise but still valuable in many cases. The determination of this relationship is based upon an evaluation of the market for a given product and an evaluation of the portion of this market that a given enterprise may reasonably expect to be its own share.

THIRD *The relationships among alternate possibilities,* the study of which makes it possible to evaluate the relative worth of alternatives and to select the best one. The complexity of this problem of *sub-optimization* which has currently received increasing attention results in part from the difficulties involved in devising the appropriate methods of measurement and computation and in part from the need for giving consideration not only to what will be done but also to what *could have been accomplished* if it had not been done.

Throughout this book a special effort has been made to show how in each specific instance an attempt could be made to measure the respec-

* The change from one standard to another under the influence of progress in the art may be likened to the shift in position of an engine governor which occurs when the speed of the engine has increased by a certain amount.

tive advantages and disadvantages of alternate possibilities: the choice between various investments, various methods of depreciation, various sales mixtures, various types of equipment. Special attention has been given to the possibility of enlarging the concept of break-even analysis to incorporate such alternate possibilities into a single mathematical model by applying the method of differential profit control.

The manager of an industrial enterprise must make decisions that will enable his business to function at a profit. Some of these decisions involve more specifically his technical knowledge; others involve his leadership and his sense of human relations; others involve his duties as a member of his community. But they are all directly or indirectly related to the economics of his firm.

Throughout this book, a special effort has been made to show how scientific methods of analysis and measurement can be used to help solve the problem of decision-making to the extent that the decision is directed by economic considerations.

Admittedly, all factors cannot be quantitatively determined with a sufficient degree of accuracy to eliminate the element of risk in decision-making. Sometimes the limitations result from practical considerations. Typically the cost of cost control may well make it prohibitive in some instances to determine the elements of manufacturing cost. Sometimes the very nature of the information required makes it impossible to proceed on the basis of scientific measurements. Typically the future developments of the national economy defy any forecasting that can be considered fully reliable—and yet most of the high-policy decisions to be made by a manufacturer are related to his own estimate of such future developments. With these reservations in mind, it can be said, however, that scientific methods of measurement and analysis have their place in industrial management with regard to the solution of economic problems.

The methods described will never provide a substitute for managerial ability. It is the manager's responsibility to make the decisions. Scientific methods of measurement and analysis do not eliminate the taking of certain elements of risk; but, when fully understood and adequately utilized, they do provide the basis for rational decisions.

PROBLEMS

CHAPTER I

1. What classes of legal instruments or certificates of ownership may a corporation exchange for the money or credit entrusted to it? What are the general characteristics of each class?
2. What is meant by the efficiency of conversion of certificates of ownership into money or credit?
3. Does the vendor who furnishes materials to a company on open accounts provide the company with part of the credit referred to in the first phase of the economic flow chart? Explain.
4. When a company obtains money or credit through selling its bonds through an investment banker and the banker charges 10 percent of the face value of the bonds for his services, is that more or less of a hazard than if the funds were raised through the sale of common stocks, also at a discount of 10 percent? Explain.
5. What are some of the criteria of efficiency in the second phase of the economic flow chart in the procurement of (a) land; (b) buildings; (c) machinery?
6. How does an inefficiency in the second phase of the economic flow chart compare with an inefficiency in the third phase so far as control is concerned? Explain by illustrative situations.
7. State what the industrial engineering profession has done to assist management in accomplishing efficiency in the third phase of the economic flow chart.

8. Explain how the second and third phases of the economic flow chart are related with respect to efficiency.
9. A manufacturer invests $1,000,000 in plant and equipment and, in addition, has $300,000 available for working capital. What inquiries should be made concerning the adequacy of the amount of working capital?
10. Illustrate by an example how the "values" of fixed assets, materials, and services flow into the values of the products of manufacture.

CHAPTER II

1. Some of the amounts stated as "values" in the balance sheet and the profit and loss statement are, in many cases, estimated values. In what sense may this be true, or untrue, of such items as:

   (a) Accounts receivable
   (b) Inventory
   (c) Machinery (depreciated value)
   (d) Current liabilities
   (e) Cost of manufacture
   (f) Net profit
   (g) Cash.

2. In a balance sheet, dated December 31, the item of interest on bonds due January 1 is not listed under current liabilities. Does this represent good accounting practice? Explain. If, in the same case, a portion of the bonds are due for retirement on October 1, should this amount appear as a current liability?
3. A company earns $500,000 in a given year. May the directors always declare any of this amount as dividends? Explain.
4. Since inventory is an item in current assets, what inquiry should be made as to the nature of the inventory before acceptance of the value stated for inventory as a sound value?
5. A company lists among its assets a value of $500,000 for dies which it uses in manufacturing its products. What inquiry should be made concerning the dies before accepting the $500,000 as a sound value?
6. A company shows a gross profit of 30 percent on sales for a given month. Some time later its monthly sales are doubled and its gross profit is 40 percent on sales. Does this seem reasonable or not? Explain.
7. Prepare a diagram to illustrate the flow of values of the asset items of the balance sheet.
8. Obtain the published balance sheet of any manufacturing company and express it in the condensed form shown in Table II.
9. Obtain the published profit and loss statement of any manufacturing company and determine the following items as percentage of sales:

   (a) Cost of goods sold
   (b) Gross profit
   (c) Administrative expense
   (d) Selling expense
   (e) Operating profit
   (f) Net profit.

(Continued on page 456)

TABLE A

CONDENSED PROFIT AND LOSS STATEMENT

(Millions of Dollars)

INCOME AND EXPENSE	All Manufacturing Industries	All Durable Goods Industries	Primary Iron & Steel Industries	Machinery (except electrical)	Motor Vehicles & Equipment	All Nondurable Goods Industries	Food	Textile Mill Products	Paper and Allied Products
Net sales	71,879	36,773	5,096	5,915	6,651	35,106	10,873	3,457	2,603
Costs and expenses	64,685	32,656	4,326	5,249	5,809	32,029	10,365	3,232	2,274
Net operating profit	7,195	4,117	770	666	842	3,078	509	225	329
Other income or deductions —net	177	41	−6	1	39	136	−3	−6	−6
Net profit before Federal income taxes	7,371	4,158	764	667	881	3,213	506	219	323
Provision for Federal income taxes	3,521	2,122	388	346	482	1,399	272	110	161
Net profit after taxes	3,850	2,036	376	321	400	1,814	234	110	162
Cash dividends	1,667	829	135	110	208	838	126	39	64
Net profit retained in business	2,183	1,207	241	211	192	976	108	71	98

TABLE B

CONDENSED BALANCE SHEET

(Millions of Dollars)

ASSETS	All Manufacturing Industries	All Durable Goods Industries	Primary Iron & Steel Industries	Machinery (except electrical)	Motor Vehicles & Equipment	All Non-durable Goods Industries	Food	Textile Mill Products	Paper and Allied Products
Cash	14,078	7,386	1,231	1,391	909	6,692	1,471	669	630
U.S. Government securities	13,180	8,027	2,087	757	2,635	5,153	613	208	616
Receivables	29,938	15,860	1,695	3,459	1,648	13,079	2,583	1,566	903
Inventories	49,026	27,761	2,516	5,764	3,914	21,265	5,053	2,765	1,276
Other current assets	3,322	1,555	260	187	172	1,767	335	126	116
Total current assets	108,544	60,589	7,789	11,558	9,278	47,956	10,055	5,334	3,541
Property, plant, and equipment—net	70,517	31,676	6,638	4,656	5,095	38,841	6,329	3,178	3,735
Other non-current assets	12,907	5,552	686	1,328	1,045	7,355	1,088	420	599
Total assets	191,969	97,817	15,114	17,542	15,417	94,152	17,471	8,932	7,876

TABLE B (CONTINUED)

CONDENSED BALANCE SHEET

(Millions of Dollars)

LIABILITIES AND STOCKHOLDERS' EQUITIES	All Manufacturing Industries	All Durable Goods Industries	Primary Iron & Steel Industries	Machinery (except electrical)	Motor Vehicles & Equipment	All Non-durable Goods Industries	Food	Textile Mill Products	Paper and Allied Products
Current liabilities	43,486	26,244	2,959	4,230	4,892	17,242	3,820	1,888	1,260
Long-term loans from banks	3,041	1,218	119	241	116	1,823	293	155	179
Other long-term debt	17,720	7,843	1,685	1,847	668	9,876	1,736	764	890
Other non-current liabilities	1,866	597	72	73	237	1,268	134	26	19
Total liabilities	66,113	35,902	4,835	6,391	5,913	30,209	5,983	2,833	2,348
Stockholders' equity	125,857	61,914	10,279	11,151	9,506	63,943	11,487	6,099	5,528
TOTAL	191,969	97,817	15,114	17,542	15,417	94,152	17,471	8,932	7,876

From the balance sheet of the same company, find the net worth and determine the net profit as a percentage of net worth.

10. A company at the close of a given year shows an operating deficit (−operating profit) and yet its net profit for that year is a substantial amount. Explain how this may come about.

CHAPTER III

1. The Federal Trade Commission and the Securities and Exchange Commission in their Quarterly Industrial Financial Report Series for all United States manufacturing corporations reported the first quarter of 1956 condensed financial statements of all the manufacturing industries in the United States. From these TABLES A and B have been selected. (The Profit and Loss Statement is for one quarter only.)
   a. Derive the significant ratios of each industry.
   b. Compare the ratios among the industries.
   c. Suggest what meaning may be attached to the comparisons.
2. What is meant by the stability of a company's financial situation?
3. Illustrate by examples a financial structure which, in your opinion, is stable, and one which is unstable.
4. Give an example of the capital structure of a company in which the common stock holdings are (a) conservative; (b) speculative.
5. Give an example of an unstable ratio of debt to net worth, and explain.
6. List the inquiries one should make in examining the significance of a ratio of current assets to current liabilities.
7. What occasions require the establishment of reserves?
8. What matter of production operation should be examined in an attempt to reduce the ratio of inventory to sales?
9. A certain company has a ratio of annual sales to net worth of 200% and makes a profit of 10% on sales. Another company has a ratio of annual sales to net worth of 300% and also makes a profit of 10% on sales. Compare the stockholders' earnings in the two cases.
10. Obtain the profit and loss statement of any company and derive its cost ratios.
11. Set up a comparative balance sheet and show what disposition is made of the earnings of the period of comparison.

CHAPTER IV

1. The corporate sales from 1929 to 1953 of all industries and the important subdivisions of industry were reported by the United States Department of Commerce.* TABLES C and D were made from these reports.

TABLE C

CORPORATE SALES—1933 to 1953

(Millions of Dollars)

Year	All Industries	Metal Mining	Food	Electrical Machinery	Wholesale Trade	Textile Mills	Railroads
1933	73,027	375	7,744	536	11,166	3,074	3,520
34	89,553	375	9,266	764	17,731	3,402	3,720
35	101,953	504	10,491	923	20,479	3,915	3,853
36	119,462	671	11,895	1,263	23,771	4,445	4,511
37	128,884	939	12,542	1,554	24,391	4,471	4,630
38	108,651	598	11,615	1,565	19,577	3,210	4,138
39	120,789	798	10,877	1,844	21,314	3,869	4,632
40	135,248	973	12,372	2,462	23,532	4,207	4,722
41	176,181	1,095	15,767	3,747	29,707	6,068	5,840
42	202,777	1,260	20,602	5,002	29,026	7,616	7,887
43	233,525	818	22,373	6,585	30,306	8,011	9,610
44	244,342	752	23,715	7,988	32,397	7,634	10,004
45	237,303	643	23,193	7,245	34,017	7,657	9,434
46	245,508	582	24,979	4,354	42,521	9,426	8,085
47	347,801	968	35,705	8,214	65,237	11,631	9,567
48	381,300	1,059	34,205	8,358	68,890	12,888	10,557
49	370,079	927	35,395	8,285	67,186	10,783	9,356
50	431,880	1,250	37,365	10,625	81,600	13,035	10,200
51	495,259	1,475	41,924	12,070	97,920	14,717	11,189
52	499,436	1,440	43,189	14,815	88,335	13,070	11,546
53	523,307	1,339	42,915	16,724	85,067	12,540	11,576

* Supplement to *Survey of Current Business,* "National Income Number."

The corporate profits before Federal and State income and excess profits taxes of the above industries are reported as follows:

TABLE D

CORPORATE PROFITS (BEFORE TAXES)–1933 to 1953

(Millions of Dollars)

Year	All Industries	Metal Mining	Food	Electrical Machinery	Wholesale Trade	Textile Mills	Railroads
1933	162	17	341	−14	94	157	−275
34	1,723	55	397	−15	217	33	−255
35	3,224	84	406	64	257	78	−174
36	5,684	140	519	135	427	189	−34
37	6,197	245	345	170	360	102	−62
38	3,329	117	360	82	142	−16	−254
39	6,467	182	543	185	358	172	−12
40	9,325	236	559	342	492	216	80
41	17,232	273	881	720	1,028	618	517
42	21,098	302	1,244	708	1,111	863	1,591
43	24,516	181	1,513	843	1,259	831	2,272
44	23,841	148	1,524	882	1,323	805	1,843
45	20,223	101	1,407	603	1,388	774	1,230
46	21,140	104	1,748	148	1,858	1,435	282
47	30,489	267	1,905	796	2,775	1,593	751
48	33,880	282	1,422	790	2,838	1,745	1,134
49	27,625	175	1,359	678	2,142	762	656
50	40,976	384	1,849	1,439	2,908	1,274	1,342
51	43,663	451	1,615	1,478	3,175	1,104	1,094
52	39,216	441	1,543	1,444	2,846	566	1,132
53	37,039	210	1,659	1,559	1,661	533	999

(a) Plot the corporate profits in relation to corporate sales for each of these industries.

(b) Derive the equation of the line of central trend (or trends) of profits *vs.* sales for each of the industries.

2. Plot the profit and loss chart of the National Cash Register Company from the following data found in Moody's *Financial Manuals (Industrial).* Determine the equation of trend (or trends) of each group of expenses in relation to sales. Comment upon your findings.

Year	Sales	Cost of Goods sold	Selling, General, Admin. Expense	Deprecia- tion	Pension Plans	Research
			(Millions of Dollars)	*	*	*
1937	42.2	18.5	18.0	...	...	...
38	36.2	17.2	15.8	...	...	...
39	37.1	15.7	18.4	...	...	...
40	38.8	17.4	17.9	...	...	...
41	52.4	24.9	21.1	...	...	...
42	79.9	45.8	23.0	...	...	...
43	99.1	65.6	22.9	...	...	...
44	93.8	61.5	24.2	...	...	...
45	68.4	39.9	26.8	...	...	...
46	77.4	43.6	31.5	...	...	...
47	138.5	67.2	51.4	...	...	...
48	168.2	78.2	63.2	...	...	...
49	167.3	75.5	63.7	...	4.7	2.4
50	170.4	78.0	57.2	5.0	2.7	2.1
51	211.9	96.0	67.6	5.4	3.1	2.1
52	226.5	101.1	78.9	7.2	3.1	2.6
53	260.9	133.1	80.4	7.9	3.7	3.8
54	259.1	128.3	86.1	8.9	2.1	5.3
55	301.2	140.0	101.9	11.1	2.1	7.7

* Data not segregated.

3. Plot the gross profit and loss chart of the Granite City Steel Company, Inc., from the following data:

Year	Sales	Cost of Sales
	(Millions of Dollars)	
1934	5.2	4.6
35	8.1	7.0
36	10.1	9.5
37	13.2	12.5
38	6.3	6.2
39	10.2	8.4
40	11.7	9.9
41	18.7	16.2
42	17.7	15.1
43	17.2	14.8
44	21.7	19.2
45	18.9	17.6
46	8.5	8.0
47	25.8	21.4
48	41.1	33.2
49	46.4	39.4
50	59.8	46.2
51	86.6	69.0
52	74.6	62.0
53	87.8	67.2
54	69.3	53.5
55	116.3	80.0

Determine the equation of trend (or trends) of gross profits in relation to sales.

4. Plot the profit and loss chart of the American Airlines, Inc., from the following data (found in Moody's *Transportation Manual*). Comment upon the trend (or trends) you have determined.

Year	Operating Revenue	Operating Expenses
	(Millions of Dollars)	
1936	8.3	8.1
37	10.1	9.9
38	11.3	10.6
39	15.1	12.6
40	20.7	18.4
41	26.3	22.6
42	27.0	21.4
43	31.4	23.0
44	39.2	29.7
45	47.4	39.2
46	68.0	68.7
47	81.7	86.2
48	89.3	91.1
49	103.2	93.7
50	118.7	98.5
51	162.9	132.8
52	187.3	160.9
53	208.3	180.8
54	214.7	193.8
55	260.7	221.4

5. The records of a certain manufacturing company were analyzed to determine the probable division of each item of total expense into variable total costs and constant total costs. The results of this analysis were as follows:

ESTIMATED MONTHLY VARIABLE AND CONSTANT TOTAL COSTS

Percent A	Percent B	Items	Cost per Month in Dollars: A Variable	B Constant	Total
		Manufacturing Costs			
100		Raw materials	31,161.92		31,161.92
	100	Direct labor	....	12,359.05	12,359.05
	100	Foremen's salaries	....	1,660.00	1,660.00
100		Operating supplies	2,068.05	....	2,068.05
100		Packing supplies	5,420.00	....	5,420.00
	100	Repairs (production departments)	....	2,572.00	2,572.00
	100	Water	....	100.00	100.00
100		Fuel	3,037.87	....	3,037.87
	100	Steam labor and expenses	....	2,355.25	2,355.25
	100	Steam repairs	....	667.00	667.00
	100	Boiler installation and fixed charges	....	126.81	126.81
81	19	Power purchased	4,173.20	1,000.00	5,173.20
	100	Power labor and expense	....	950.00	950.00
	100	Power repairs and maintenance	....	318.00	318.00
	100	Fly wheel installation and fixed charges	....	125.32	125.32
33	67	Sub packing station power	40.00	80.60	120.60
	100	Refrigeration labor and expense	....	473.00	473.00
	100	Refrigeration repair and maintenance	....	426.00	426.00
	100	Refrigeration fixed charges	....	12.25	12.25
33	67	Sub packing station refrigeration costs	150.00	299.70	449.70
	100	Salaries, supervision of plant	....	1,590.00	1,590.00
	100	Salaries, superintendent of plant (fixed charges)	....	5,600.00	5,600.00
	100	General repair and maintenance	....	971.00	971.00
	100	Plant office expenses	....	1,575.00	1,575.00
33	67	Trucking, salaries, and expenses	291.00	600.00	891.00
	100	Trucking, fixed charges	....	262.68	262.68
	100	Yard costs	....	1,225.00	1,225.00
	100	Liability and compensation insurance	....	273.95	273.95
	100	Experimental expenses	....	800.00	800.00
	100	Traveling expenses	....	400.00	400.00
	100	Unclassified general expenses	....	28.00	28.00
	100	General taxes	....	309.29	309.29
	100	Fire insurance, general	....	428.27	428.27
	100	Depreciation	....	3,699.50	3,699.50
		Total manufacturing costs	46,342.04	41,287.67	87,629.71
		Less destroyed and samples	633.20	....	633.20
53	47	Net manufacturing costs	45,708.84	41,287.67	86,996.51
100		Freight and express	16,545.79	....	16,545.79

Percent A	Percent B	Items	Cost per Month in Dollars A Variable	B Constant	Total
		Branch Operating Costs			
100		Gasoline and oil	3,287.22	....	3,287.22
100		Tire repairs	207.65	....	207.65
100		Auto repairs	1,650.05	....	1,650.05
100		Express and parcel post (outgoing)	1,232.25	....	1,232.25
100		Refrigeration, ice, etc.	1,134.50	....	1,134.50
100		Reserve for bad debts	2,000.00	....	2,000.00
	100	Salaries	....	29,420.40	29,420.40
	100	Other branch expenses	....	11,478.04	11,478.04
19	81	Total branch operating	9,511.67	40,898.44	50,410.11
	100	Division sales expense	....	11,690.00	11,690.00
	100	Administrative, and general sales expense	....	18,720.90	18,720.90
		Total administrative, general sales division sales expense	....	30,410.90	30,410.90
39	61	TOTAL COSTS	71,766.30	112,597.01	184,363.31

The above estimate is based on a production of 1,000,000 pounds of product per month. The company manufactured a food product which was sold to the baking trade by the pound. It had 65 branches throughout the United States and two manufacturing plants. The product was sold at an average price of 20.5¢ per pound.

Thus lay out the break-even chart for this company for a range of production up to 1,500,000 pounds per month, with the base of the chart in units of 100,000 pounds per month. Show the total expense trend, net manufacturing cost trend, and the trend of total expenses before administration and general sales expense.

6. Construct a break-even chart from the above data with the base laid off in units of income in which the income line is at 45°. If the selling price of the product should be reduced to 19¢ per pound, at what income will the company break even? Draw the total expense line for this condition in a broken line on the chart. How much more business must be done to make the same profit as before?

7. A certain merchant went to his banker to obtain a loan of $20,000. He stated that current operations of his business were profitable and produced certain statements to support his assertions. The banker asked him the following questions and received replies as indicated.

Q. What is the average mark-up of your product?
A. 100 percent.
Q. How much is the total of rent, insurance, depreciation of equipment, and other items of fixed charges?
A. $20,000 per month.

Q. Are all employees on salary; is each necessary to the conduct of the business; what is the total of the monthly salaries?
A. All employees are on salary and each is necessary to the business. The total of their salaries is $7,000 per month.
Q. What other expenses are incurred in operating the business?
A. $1,000 per month for supplies, etc., and these are about the same each month regardless of sales.
Q. How much business must be done per month to break even?
A. About $40,000 per month.
Q. What is the anticipated average of the next 6 months' sales?
A. $50,000 per month.
Do you think the banker granted the loan?

CHAPTER V

1. The following data have been reported by the Studebaker Corporation (prior to its merger with the Packard Corporation) and by the Studebaker-Packard Corporation (for the years preceding and following the merger, which took place in 1954):

THE STUDEBAKER CORPORATION

Year	Sales	Cost of Goods Sold	Selling, General Admin. Expenses
		(Millions of Dollars)	
1947	268.0	244.2	7.4
48	383.6	340.8	8.9
49	473.1	415.0	12.3
50	477.0	426.1	12.4
51	503.3	468.0	12.5
52	585.3	540.4	15.5
53	594.2	569.3	19.6

STUDEBAKER-PACKARD CORPORATION

Year	Sales	Cost of Sales	Selling, General Admin. Expenses
		(Millions of Dollars)	
1947	138.3	128.6	10.6
48	231.9	196.6	11.7
49	212.6	187.3	13.4
50	173.4	153.5	12.9
51	178.2	155.7	12.7
52	233.7	205.7	16.1
53	335.8	304.7	19.4
54	222.3	241.0	22.9
55	480.0	470.4	40.8

Using the above data:

a: Prepare the Profit and Loss Chart of the Studebaker Corp.
b. Prepare the Profit and Loss Chart of the Studebaker-Packard Corp. (Packard Motor Co. prior to the 1954 merger.)
c. Comment upon these two charts. You may, at your option, use additional information, such as that provided in the article, "The Breakdown of Studebaker-Packard," in *Fortune*, October, 1956.
d. Compare these two charts to the profit and loss chart of the General Motors Corp., as shown in Chapter V, and comment upon the comparison.

2. The General Foods Corporation reports the following data for the years 1934 to 1955:

Year	Net Sales	Net Income before Taxes	Cost of Goods sold
		(Millions of Dollars)	
1934	103.0	13.0	65.1
35	107.4	14.5	66.7
36	122.4	17.3	77.5
37	133.1	11.0	93.3
38	135.2	16.4	88.3
39	145.6	18.5	94.0
40	152.9	20.5	99.8
41	180.3	26.7	117.1
42	231.5	32.5	163.3
43	259.8	35.4	185.8
44	296.5	30.1	222.2
45	307.0	28.4	236.9
46	330.9	34.8	252.9
47	407.3	29.8	324.8
48	463.3	40.0	362.8
49	474.6	43.6	362.5
50		–*(Change in accounting period)*–	
51	589.2	50.5	454.9
52	632.5	50.7	491.3
53	701.0	59.4	536.8
54	783.0	64.7	598.3
55	824.8	70.5	621.1

a. Compute annual total expense (net sales–net income before taxes).
b. Plot total expenses in relation to net sales and derive the equation of trend (or trends).
c. Plot cost of goods sold in relation to net sales and derive the equation of trend (or trends).
d. Compute annual administrative and selling expense (total expense–cost of goods sold).
e. Plot administrative and selling expense in relation to net sales and derive the equation of trend (or trends).

3. The following data are reported by the United States Gypsum Company in its annual reports to the stockohlders:

Year	Net Sales	Net Income before Federal Taxes
1934	$ 15,950,000	$ 2.373,763
35	22,597,344	3,949,615
36	33,541,342	6,300,113
37	38,345,023	6,320,010
38	35,143,862	5,596,497
39	43,334,697	8,722,599
40	50,694,233	11,184,974
41	63,455,661	14,214,629
42	62,225,140	12,875,316
43	59,266,127	10,154,450
44	62,329,573	7,783,187
45	65,786,336	9,027,183
46	85,360,686	20,443,955
47	108,405,538	26,376,744
48	148,555,269	39,163,688
49	137,838,114	34,885,608
50	174,779,850	53,661,518
51	188,125,170	52,713,261
52	184,900,386	46,357,216
53	194,589,946	47,632,708
54	216,997,318	63,949,015
55	258,685,548	76,486,967

a. Compute total expense before Federal taxes.
b. Plot total expense before Federal taxes in relation to net sales and derive the equation of trend (or trends).

CHAPTER VI

1. Assume that the total expense trend of the ABC Company, as reported on page 168, is $4,500,000 + 60% sales.

   a. What would be the equation of profit before Federal taxes?
   b. If the capitalization should be $12,000,000, 5% cumulative preferred stock, and $25,000,000 common stock, what would be the profit on the common stock before Federal taxes for annual sales of $17,000,000?
   c. How many times would the company have earned its bond interest for both maximum and minimum sales for the period?
   d. What is the equation after bond interest and Federal income taxes?

2. The total expense trend of a company's present break-even chart is $6,000,000 + 60% of sales. The company has $3,000,000 in 6% bonds

outstanding; \$10,000,000 in 5% cumulative preferred stock; and 1,000,000 shares of no par value common stock.

Determine the following for annual sales of \$20,000,000:

a. The number of times bond interest may be earned.
b. The number of times the dividends on preferred stock may be earned.
c. The amount earned on common stock before Federal income taxes.

3. What effect on the earnings of the beet sugar company referred to on page 164 would result if the sugar content of the beets were 16 percent, percent of extraction 90 with a 5 percent shrinkage, and the molasses were reduced to 1 percent, but the selling price of both molasses and pulp were increased 20 percent, and all other factors were the same? Show the effect by a table of cents per pound cost at varying annual production.

4. Two companies, each with annual sales of \$3,000,000, make a net profit of 15 percent on sales. If one company (A) has constant total costs of \$800,000 and the other (B) of \$300,000, how do they compare with respect of earnings over a range of sales, when (A) has 50 percent more capacity than (B)?

5. A certain manufacturer in Detroit, anticipating an increase in business, enlarged and mechanized his factory. His total expenses before factory enlargement followed the trend \$500,000 + 76% of sales. The plant enlargement increased the constant total costs 80 percent and reduced the variable total cost factor by 5 percent. How much more business than former full capacity (\$4,000,000 sales) must the company do to earn the same as it did at former full capacity?

CHAPTER VII

During the year 1956, the N— Corporation sold \$15,000,000 of manufactured goods.

The total expenses for the same period were \$12,000,000, including the following items of variable and constant expenses:

THE N—— CORPORATION

	Total Expense	Percent Variable	Variable Expense	Constant Expense
Direct labor	\$2,000,000	100%	\$2,000,000	...
Direct material	5,000,000	100	5,000,000	...
Factory overhead	2,000,000	40	800,000	\$1,200,000
Selling expense	2,000,000	60	1,200,000	800,000
General administrative expense	1,000,000	0	...	1,000,000
TOTAL	\$12,000,000	=	\$9,000,000 +	\$3,000,000

Answer the following questions:

Problem 1. On the basis of the above data, how many dollars of sales are required for the N—— Corporation to break even?

Problem 2. Assuming that there will be no substantial change in expense trends in 1957, what will the probable profit or loss be if the N—— Corporation experiences a reduction of sales to $10,000,000 for the year 1957?

Problem 3. What is the amount of reduction in constant cost (regulated cost) needed for the N—— Corporation to break even at $5,000,000 of sales (assuming that there is no change in the variable expense trend nor in the fixed expense)?

Problem 4. In December, 1956, the N—— Corporation faces a demand by the union for a 10 percent increase in wages in the form of a cost of living bonus. At the same time the raw material cost increases by 16 percent. Other expenses and selling prices remain at the same level as in 1956 (see data above). Prepare the probable break-even chart of the N—— Corporation for the year 1957.

Problem 5. a. Using again the original data given for the year 1956, prepare the break-even chart of the N—— Corporation *as it would be* if the selling price were reduced by 10 percent.
b. Where would the break-even point be in such a case?

Problem 6. The N—— Corporation is considering the purchase of new equipment to be installed in 1957.

It is estimated that if this new equipment had been available in 1956, the variable expense would have been reduced to $6,000,000 (instead of $9,000,000), due to a saving in labor cost. It is also estimated that the constant expense would have been increased to $5,000,000 (instead of $3,000,000), due to an increase in depreciation charges.

a. On the basis of this estimate and assuming that no other changes are expected in the expense-sales relationship and also that the future sales will remain at approximately the same level as in 1956, is it advisable for the company to buy the new equipment?
b. Would it still be advisable if the sales were expected to drop to $8,000,000?
c. What if the sales should stabilize around $10,000,000?

7. In the case of the gas wells (page 205), assume that:

a. Average drilling cost $10,000.
b. Annual operating and overhead cost per well $800.
c. Price of gas at well per MCF was 20¢.

All other factors were the same as given on page 205.
Reconstruct the table given on the page following and the break-even chart, Figure 49.

8. In the case of the pipe-line (page 207), assume that the investment is \$20,000,000, that the gas is purchased for resale at 6¢ per MCF and sold at the terminal at prices varying from 25¢ to 10¢ per MCF, the highest priced gas being sold first, such that gross revenues are 10 percent higher in each case as reported in the table. Also assume that cost of compressing station fuel and operating cost are the same and that pipe-line operating costs and management costs are 10 percent higher. Reconstruct the table and the break-even chart, Figure 50.

9. In the case of the silk mill referred to (page 208), prepare a table of mill allowances for indirect labor, indirect supplies, machine repairs, miscellaneous expense, and power as well as the total of these, for 20, 40, 60, 80 and 100 percent activity. The data of Figure 51 is to be used in preparing this table.

Use the data given on page 183 for the following problems:

Problem 10. Construct the break-even charts (annual basis) for each product and for the business as a whole.

Problem 11. Construct the break-even charts of each territorial division to carry its own expenses from the data on page 187 and verify the expense trends and break-even points which follow.

Problem 12. Construct the break-even charts of each division to carry its own expenses plus its portion of manufacturing and administrative expense from the data on page 189 and verify the break-even points stated in the text.

CHAPTER VIII

1. What sum of money invested at 4 percent simple interest will amount to \$1,000 in 5 years?

2. If the sum determined above were invested for 5 years at 4 percent interest, compounded annually, what would the compounded amount be?

3. If you had promised to pay \$10,000 at the end of 15 years with interest compounded annually at the rate of 5 percent, what sum of money compounded annually at the rate of 3 percent would have to be deposited today to meet this obligation?

4. A young man 20 years of age has a legacy of \$100,000 to be paid him at the age of 30 years. He wishes to spend the next 7 years in acquiring a medical education which he estimates will cost him \$2,500 per year. Each year, beginning at the age of 20, he sells part of his legacy on a 6% present worth basis to realize \$2,500 to defray his expenses. How much will his equity in the legacy be when he becomes 30 years of age?

5. A manufacturer wishes to expand his business, for which he needs \$100,000. He obtains the loan from a private person on the following basis. Because of the speculative features of the business, the lender

wants 8 percent on his money compounded annually and to be paid in ten years. As further protection he requires the borrower to make monthly deposits in a savings bank at 3 percent compounded annual interest so that the savings bank fund will equal the amount he is to be paid at the maturity of his loan. How much must the annual savings deposits be?

6. How much should you pay for an apartment house on the basis of the following data? Anticipated net monthly income (rent – expenses) $5,000. Estimated resale value at end of 15 years $50,000. Net monthly incomes assumed to be deposited at 4 percent compound annual interest. Return on investment 8 percent.

7. What sum of money invested now at 4 percent interest compounded semiannually will be just sufficient to pay $1,000 two years from now, $1,000 four years from now, $1,000 six years from now, and $1,000 eight years from now?

8. A man has a savings account in a bank which pays 3 percent interest compounded annually. He opened his account with a deposit of $3,000, and no deposits or withdrawals have been made since. If his balance is now $13,380, how long ago did he open the account?

9. With interest at 5 percent compounded annually, how much money could be borrowed today to be completely repaid by a payment of $500 five years from now and $500 ten years from now?

10. A manufacturer estimates that by the use of a new piece of equipment he can save $1,000 per year in operating costs, including capital recovery through depreciation. The life of the equipment is estimated to be 5 years. On the basis of 3 percent interest on savings and 7 percent interest on the investment, what is the top price he can afford to pay for the equipment?

CHAPTER IX

1. A machine purchased for $500,000 is estimated to have a useful life of 15 years. Plot the book value of the machine for each year of its expected life, according to each of the following methods for accounting for depreciation:

   a. Straight line
   b. Sinking fund at 4 percent
   c. Diminishing balance with a scrap value of $2,000 at the end of 15 years
   d. Sum of the years-digits.

2. A company pays $75,000 for a diesel engine for its power plant. Freight and haulage amount to $2,000 and installation in the plant costs $5,000. The estimated life of the engine is 20 years and the salvage value at that time is estimated to be $4,000. Find the book value at the end of each year of its life, using:

a. Straight-line depreciation
b. A 3 percent sinking fund
c. Diminishing balance depreciation
d. Sum of the years-digits.

3. Determine the charge of the cost of production for each year for each of the above methods.

4. If a machine costing $50,000 in 1948 is to be replaced in 1958, but at a cost of $65,000, how much should be charged to depreciation each year by the straight-line method? Why?

5. What is the reason that tax legislation allows only that rate of depreciation which will permit of the recovery of the original investment?

6. What justification is there for charging annual depreciation according to the volume of annual sales?

7. Why are bondholders interested in having a company use high rates of depreciation while stockholders favor low rates?

8. The total cost to a company of a new lathe, installed and ready to operate, is $8,000. It is estimated that this machine can be sold for $500 at the end of 15 years. Determine the yearly depreciation charge, the total depreciation, and the book value at the end of the fifth year by means of the straight-line method.

9. A manufacturing company is in the market for a machine to fabricate one of its products. The piece may be made on a turret lathe at a cost of 12¢. The turret lathe would cost $4,500 and its expected life is 10 years, with a $500 salvage value at that time.

   The product can also be made on an automatic screw machine at a unit cost of 10¢. This machine is priced at $7,500 and it is expected to last 15 years with no scrap value.

   If the annual output of the plant is 10,000 pieces, which machine would you recommend to the company if a straight-line depreciation system were used?

   How would your decision be affected if a 6 percent sinking fund were used instead?

10. A truck costs $4,500 when new and its life expectancy is 8 years. It is anticipated that its scrap value will be $200. By means of the diminishing balance method, calculate the depreciation charge for the sixth year and the book value at the end of that year.

CHAPTER X

1. Classify the types of labor (direct or indirect) engaged in the following operations:

   a. Operating a milling machine in a toolroom
   b. Operating a comptometer in the accounting office of a factory

c. Operating a paint spray machine in an auto-body works
d. Oiling the line shaft bearings
e. Operating a punch press in a structural iron works.

2. Classify the type of material (direct or indirect) used for the following purposes:

   a. Varnish to finish furniture
   b. Tool steel for making lathe tools
   c. Coal for the factory power plant
   d. Coal for a heating furnace in a forge shop
   e. Gears purchased for use in the product sold.

3. In what division of expense does each of the following belong?

   a. Foreman's salary
   b. Fire insurance on factory
   c. Insurance on life of the president
   d. Depreciation on delivery equipment of sales division
   e. Service of a consultant on factory wage system.

4. A manufacturer has three items of inventory of materials purchased at prices as indicated below:

Date	Material	Amount Pounds	Purchase Price per Pound
Aug. 11	A	500	10¢
Oct. 20	A	1,000	12¢
Sept. 7	B	600	20¢
Nov. 11	B	800	23¢
Oct. 30	C	900	32¢
Nov. 20	C	1,500	35¢

During December the quantities of materials costed into the products sold are as follows:

Material A	1,200 lbs.
B	500 "
C	2,000 "

At what costs will the materials A, B, and C be entered into the cost of manufacture for December by each of the following methods: (a) Average cost, (b) FIFO, and (c) LIFO?

Which of these are readily acceptable to the Federal tax authorities?

Why would any company use a method not readily acceptable to the Federal tax authorities? What problem of accounting arises in the use of non-acceptable methods?

CHAPTER XI

1. In a given process industry the materials pass through seven major processes, which are designated

A, B, C, D, E, F, and G.

The following facts have been established concerning each major process.

ITEM	Major Processes						
	A	B	C	D	E	F	G
	Percent of Total						
Floor space	10	15	5	20	5	15	30
Value of equipment	5	20	10	25	10	10	20
Power consumed	15	5	10	10	15	20	25
Labor (indirect)	10	15	5	15	10	15	30
Supplies	15	15	15	10	15	15	15

The annual depreciation, insurance, and taxes on the building total \$150,000. The annual depreciation, insurance, and taxes on equipment total \$320,000. The monthly power bill averages \$10,000. The monthly (indirect) labor payroll is \$30,000. Supplies cost \$1,500 per month. Heating and lighting averages \$3,000 per month.

Determine the monthly amounts of each item and the totals of the above factory expense for each major process and for the plant as a whole.

2. The records of a certain manufacturing company for a given month show the following:

Cost of manufacture	
Materials	\$45,000
Labor (direct)	20,000
Factory expense	20,000
Direct-labor-hours	16,000

Product X incurs a material cost of \$2.00 and a labor cost of \$4.00 in 4 labor-hours. What is the estimated cost of manufacture by the direct-labor-hour method from the above facts?

3. In the above example a more detailed examination of factory expense and direct-labor-hours shows the following:

		Department			
	Total	1	2	3	4
Factory expense	\$20,000	5,000	10,000	2,000	3,000
Direct-labor-hours	16,000	4,000	6,000	4,000	2,000

Product X is worked on for 3 hours in Department 2 and 1 hour in Department 4. What is the estimated cost of manufacture by the direct-labor-hour method from the above facts?

4. The business to which Table XLIII relates finds that, owing to rising costs, the following increases are had in each of the following items: taxes 10%, insurance 5%, labor 30%, materials 40%, supervision 25%, depreciation no change, all service departments 25%. The distribution to the productive departments is unchanged. The direct-labor-hours and their distribution by departments are also unchanged. Determine the new hourly rate for each productive department and for the factory as a whole.

5. A manufacturer uses the percentage on wages method for allocating factory expense. Selecting appropriate data showing that the four departments of his business have widely different factory expenses and direct-labor hours, write him a letter in justification of the use of departmental factory expense allocation by direct-labor-hours.

6. A manufacturer accounts for depreciation as a single account and as a deduction from gross profit. He now wishes to have it allocated as part of the cost of manufacture. Assuming the appropriate data for illustrative purposes, write a letter to an assistant instructing him how to make such an allocation.

7. A certain company houses its factory and administrative and sales offices in one building. The factory occupies 90 percent of the floor space, and sales and administration occupy 10 percent. In the factory, 75 percent of its space is occupied by productive departments and 25 percent by service departments. The power plant provides heat, light, and power and is housed in a separate building. Fifty percent of its output is used to provide power to operate the factory. The other 50 percent of output is used to light and heat the entire building.

   Set up a table of distribution of the cost of light, heat, and power to the factory and its productive and service departments and to the administrative and sales offices.

8. A certain company maintains an engineering and drafting department which makes designs and blueprints for use in production and also makes designs and blueprints for the tool department and the pattern shop. The question arises as to how much of the annual cost of maintaining the engineering and drafting department is to be charged to the tool department and how much to the pattern shop. Suggest an equitable solution of this problem.

CHAPTER XII

1. A beet sugar mill is estimated to have constant total expenses of $1,500,000 per annum. Its capacity is 250,000 tons of beets per annum. The yield is 230 pounds of sugar per ton and pulp and molasses which sell for $450,000 per annum. The variable total expenses for full capacity operations are $1,600,000. Crediting pulp and molasses sales to reduction of operating costs, what is the constant unit cost per ton? What are the variable unit costs and the total cost per ton for from 40 to 100 percent capacity operation? Graph the data on costs.

2. A certain automobile manufacturing company produces automobiles at a yearly total expense of $100,000,000 plus 75 percent of sales. Its automobiles sell to the dealer for $1,750 each. Its maximum capacity is 1,200,000 automobiles per annum. What is the cost per automobile for from 40 to 100 percent capacity operations?

3. A certain machine costs $10,000 and has an estimated useful life of 5 years. Insurance and taxes are at the rate of 3 percent each. It is operated by a workman who receives $1.50 per hour. The machine can do a particular operation at a maximum rate of 10 per hour. The shop operates for 2,000 hours per year. Determine the cost per operation for from 20,000 to 5,000 operations per year under each of the following conditions:

   a. Machine always run at maximum capacity; workman assigned to other jobs when the machine is idle.
   b. Machine always run at maximum capacity; machine adjusted to perform other operations when the above particular operation is not being performed.

   Graph the results in each case.

4. What do you think of the direct costing method:

   a. For the purpose of pricing a new item?
   b. For the purpose of sales mixture control?

   Explain your point of view.

5. If you were responsible for high-policy decision in a business, would you agree to sell an item at a price under its direct cost? If so, under what conditions? Would you consider selling it at a price above its direct cost, but below its full cost, after allocation of overhead costs, and if so, under what conditions would you agree to do it?

   Explain your decision.

6. List all the factors which, in your opinion, should be considered when pricing a new item for a manufacturing company that makes and sells about 5,000 different items and whose total sales amount to about 10 million dollars a year.

CHAPTER XIII

1. Two lathes (A and B) compare as follows:

Prices	A = $2,750	
	B = $3,200	
Speeds	A	360, 300, 180, 90, 60
	B	300, 190, 100, 40, 12
Torques, foot-pounds	A	2, 2.5, 4, 8, 15
	B	1.5, 2, 3.5, 10, 18

Lay out the torque-speed diagram of each lathe. Let the area of Diagram A = 1. How do the prices compare in terms of power-capacity?

2. A purchaser must decide between two machine tools, each of which is capable of doing the required job. They compare as follows:

	Machine A	Machine B
Investment	$5,000	$8,000
Annual percentage of fixed charges	12%	18%
Hourly wages	$1.25	$1.10
Hourly service charge	$1.00	$1.00
Pieces produced per hour	6	9
Annual shop hours	2,000	2,000

Which machines will give the lower cost per unit of output for both machines operating continuously throughout the year?

3. If, in the above example, the machines could not be used on any other kind of work, and the annual production to which they are adapted is 6,000 pieces, which then would give the lower cost per piece?

4. Power may be provided for a factory by a steam plant, a diesel engine plant, or through purchased power and the use of a motor. The capacity is to be 1,200 hp and the plant is to operate 4,000 hrs. per year. The proposals compare as follows.

	Steam	Diesel	Motor
Investment	$90,000	$150,000	$12,000
Fixed charges in percent	16	18	15
Labor and service cost including fuel per hphr.	1.1¢	0.8¢	1.5¢
Estimated life	20 yrs.	12 yrs.	25 yrs.

The motor has an efficiency of 92 percent. Which is the best investment and why?

5. A certain job in a factory is performed by the use of several very simple jigs. It requires 4 hours to do the work and the labor cost is $2.50 per hour. Two thousand pieces per year are required. It is proposed to design and build a more complicated jig for this job, which, it is estimated, will

allow the job to be done in 2 hours at a labor cost of $2.00 per hour. The jig will cost $2,000 and carry an annual cost for depreciation, repairs, etc., of 60 percent. The service charge on labor will be 100 percent in each case. Will it pay to construct the jigs, and, if so, what annual saving will result? Below what annual production will it not pay to construct the jig?

6. An alumnus decides to present his alma mater with a new power plant and to establish an endowment for its operation and maintenance by giving the college some 6 percent bonds. What should be the total face value of the bonds under the following circumstances: The power station is to be a 1,500-horsepower steam electric plant costing $125 per horsepower. The average operating cost is 0.5¢ per horsepower-hour, and insurance and depreciation are estimated to be 6½ percent annually. There are no taxes to be paid. The estimated useful life of the plant is 20 years. The plant will run practically continuously for 9 months in the year.

7. The proprietor of a small machine shop has $10,000 available for capital investment in his business. He finds that two opportunities present themselves:

   a. To buy a machine for $8,000, which will reduce the cost of manufacture of a certain product 10¢ per piece at the current annual output of 15,000 pieces, which is the capacity of the machine to be replaced. This machine can produce 25,000 pieces annually at a reduction in cost of 12¢ per piece. If he reduces his selling price 3¢, he can increase his annual sales from 15,000 to 25,000 and make a profit of 16¢ per piece. He can invest the remaining $2,000 at 6 percent interest. The investment in the machine to be replaced has been fully recovered through depreciation charges and has no scrap value. The new machine has an annual production capacity of 35,000 pieces.
   b. To revamp his power plant at a cost of $10,000 and save $3,000 per year, provided the cost of fuel remains unchanged.

   Which is the better investment?

8. A certain manufacturer has the problem of producing 30,000 parts annually and selecting the most economic lot size to be equally spaced during the year. The annual cost of housing the average inventory and the interest on the investment in inventory when the whole annual requirements are produced in one run is $1,000. The cost to set up and dismantle the machine plus other service incidental to starting a production order is $25. What is the economic lot size?

9. Why do not the cost to possess and the cost to operate appear as factors in the determination of the best lot size, except, of course, as these costs enter into the value of inventory?

10. Plot values z, r, and z + r in the above example for values of k from 1 to 12. Compare the minimum ordinate of the plotted data with the results obtained in Problem 3.

11. Referring to the study of Step 5 of the analysis and measurement of the relative worth of alternatives (page 345), what progress, if any, has been made, since this book was written, to simplify the computing procedures utilized to determine the optimum solution of a mathematical model?

CHAPTER XIV

1. Referring to the discussion on page 374, it is said there that the case of "issuing certificates or claims to goods not paralleled by the production of goods" is "bringing us nearer to an understanding of what is happening in our economy." Do you agree or disagree with this statement? Why?
2. On December 31, 1947, the index of retail food prices was 206.9 (1935–1939 = 100). Does this increase indicate a fluctuation in prices of retailed food or a variation in the value of the dollar? Why?
3. What is the most generally used form of money in the United States today: gold currency, paper currency, or bank credits?
4. After 1945, the total amount of bank-held Government securities declined. What was the effect on the trend of total money supply? Does this decline in bank-held Government securities after 1945 indicate more inflation or less inflation?
5. Why are so many businessmen concerned about the replacement value of their fixed assets in times of inflation?
6. What is the fundamental difference between credit inflation and monetary inflation? Illustrate by examples.

CHAPTER XV

1. Define "effective demand." What is the difference between customers' needs and customers' effective demand?
2. If you were manufacturing goods for elderly people, would you expect a substantial increase of your market in 1970? Why?
3. If you need a reliable forecast of the United States population in 1995, can you find it? Where?
4. What is the difference between cash sales and installment sales? Are installment sales sometimes dangerous for the national economy? If so, when and why?
5. a. What is the "available income of a customer in regard to a given product"? Illustrate by a few examples.
   b. Why is the available income a "subjective" evaluation? What about the "disposable income"? Illustrate by an example.

6. Why, in your opinion, was the regulation restricting consumer credit (Regulation "W"), which ended soon after the war, reinstated in 1948? What do you think of the present regulations or lack of regulations with regard to consumer credit (by present is meant the time that you are working on this assignment)? Why is consumer credit at all permitted by law? What would happen if it were not?

7. Under what circumstances would you, as a manufacturer, apply for credit insurance?

Year	Disposable Personal Income	All Stores	Non-durable Goods	Durable Goods	Department Stores
			(Millions of Dollars)		
1929	83,120	48,459	32,842	15,610	3,903
35	58,322	32,791	24,470	8,321	2,833
39	70,444	42,042	30,730	11,312	3,408
45	150,355	78,034	62,008	16,026	6,484
50	206,130	143,689	90,754	52,935	9,403
51	226,069	152,975	99,805	53,170	9,846
New Series					
51	226,069	158,223	103,744	54,479	10,095
52	237,374	164,085	108,815	55,270	10,277
53	250,235	170,741	110,370	60,371	10,370
54	254,403	170,664	112,491	58,173	10,272
55	270,573	185,479	118,501	66,978	10,882

Note: The New Series are not comparable to preceding years because of a change in the methods of computing retail stores sales. See *Survey of Current Business*, Sept. and Nov., 1952.

8. The preceding data are taken from the *Statistical Abstracts of the United States*.

   a. Plot the sales of all stores against disposable personal income and derive the equation of trend or trends
   b. Same for non-durable goods stores
   c. Same for durable goods stores
   d. Same for department stores.

CHAPTER XVI

1. During the period 1825–1954, the coal production (in thousands of short tons) varied as follows in the United States (source: *Statistical Abstract of the United States*):

1825	141	1920	658,265
35	1,032	25	581,870
45	4,535	30	536,911
55	12,513	35	424,532
65	20,538	40	512,257
75	52,179	45	632,551
85	107,291	50	560,388
95	178,822	53	488,240
1905	339,357	54	421,083
'15	529,189		

Using the above data, plot the growth curve of the coal mining industry in the United States. Compare with the growth curve of the automobile industry (Figure 79). Comment.

2. If, in a given industry, the new customers' market decreases very substantially, is this a factor that might encourage the industry to reduce the quality of its production?

3. What is the most favorable stage in a given industry's expansion for standardization to begin? Why?

4. Has standardization already begun on a large scale in the automobile industry? Why?

5. Did not standardization begin at an early stage in the typewriter industry? Why?

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